MACHINERY.

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AMONG THE SHOPS.

NOTES TAKEN ON THE MANUFACTURE OF MACHINE TOOLS AT THE SHOPS OF PRENTICE BROS. COMPANY, WORCESTER, MASS.

Among the various industries represented by the fourteen hundred shops and factories located in Worcester and the immediate vicinity, that of machine-tool building occupies a prominent position. The initial development of Worcester in the manufacture of machine tools and other products is thought to be due to the early introduction of steam power and the building of railroads giving good shipping facilities. Be it as it is, the tool building firms there represented are generally well known at home and abroad as makers of first-class machines.

Prominent among the well-known firms is that of the Prentice Bros. Company, builders of lathes and drilling machines.

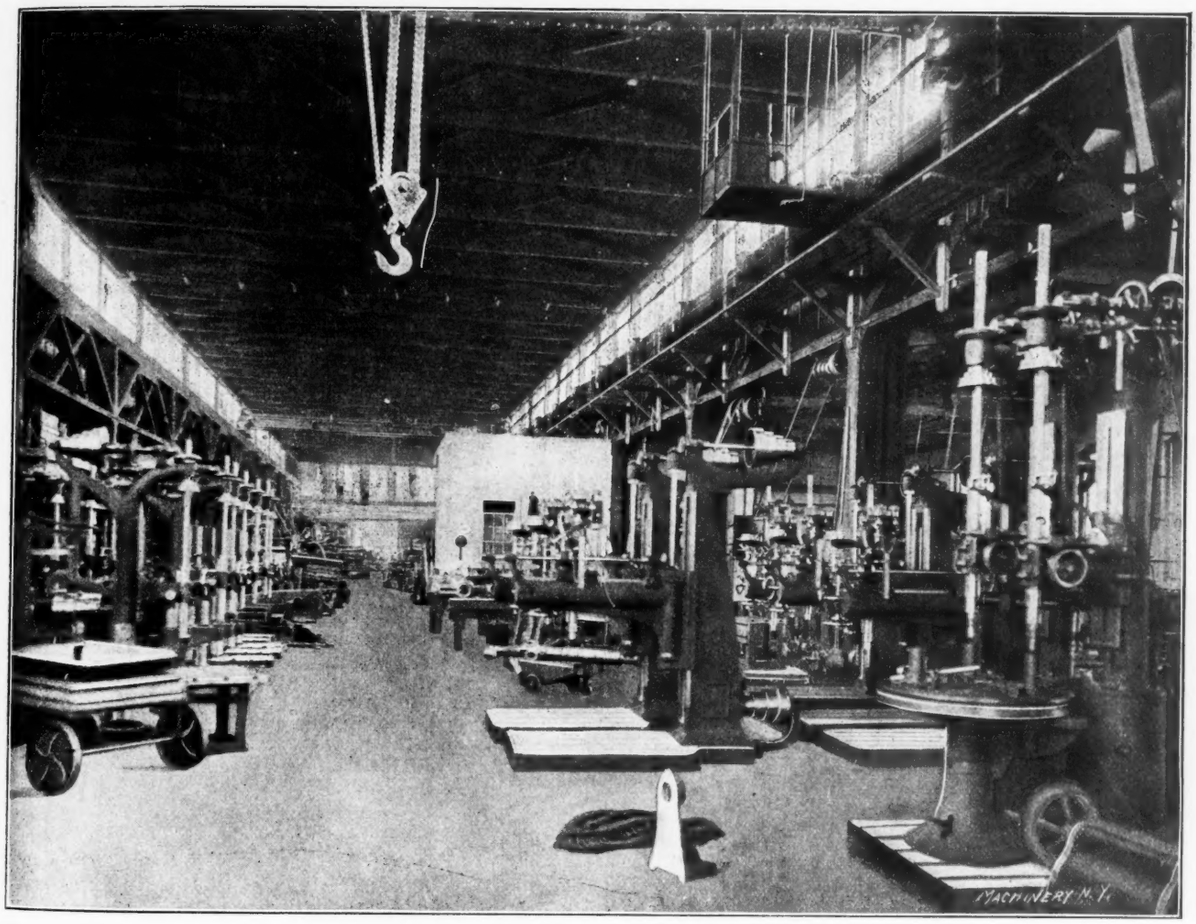


Fig. 1. Main Erecting Floor 320 Feet Long, Looking North.

Following the general trend of manufacture to specialize, they have so far generally confined their efforts to these lines. Their capacity for building tools is about 600 lathes and 1,800 drillers of all sizes per year. The sizes of the latter range from those weighing 750 to 34,000 pounds; of lathes, up to 24" swing with 20' bed.

The main shop, illustrated in Fig. 1, is 320 feet long, with a monitor roof and two traveling cranes of fifteen tons capacity running the full length. There are, in addition, two annexes, one on each side, connected to the main shop by short covered passage ways, which enable all three buildings to receive light from both sides and yet make them the same as one as far as doors are concerned. The annexes are two stories in height, one containing the lathe scraping and fitting department, storage and pattern shop on the first floor, and the drafting room and storage on the second; the other, the grinding machinery, turret machines, headstock department, etc.

All heavy work is, of course, done on the main floor where the planers and other tools can be served by the power cranes. The lighter work, not requiring cranes for handling, is done in the annexes. The different classes of work are handled by gangs over which is a working foreman, subject to the general foreman and superintendent. Each gang has some specialty and thus each one becomes expert in the production of his specialty. The general use of jigs and fixtures accompanied by a close system of inspection, standardizes the work and secures uniform accuracy.

The smaller classes of drillers are put through the shop in large lots, often two hundred at a time. Such a wholesale business of manufacturing any one type of tool has necessarily resulted in some interesting methods.

Small cast-iron parts subject to working stress such as gears, etc., are annealed before machining by being packed in cast-iron boxes with cast-iron chips and kept red hot for about twenty-four hours, the time depending somewhat on the size of the

pieces. In this way the internal stresses due to cooling are neutralized and the casting made softer, so that it will not so likely break under sudden stress. This method of treatment has been found very satisfactory, both from the manufacturing side and in increasing the durability of the machines. The driller columns are centered for the lathe in a special machine shown in Fig. 5, which shows a rough column held in a horizontal position by the jaws grasping the part to be turned. The centering spindles at each end are then brought into action and the column centered so that it will clean up regardless of the eccentricity which may result from a rough or slightly sprung casting. The jaws grasping the column are operated by right and left screws through the handwheels at the back. The jaws themselves are cut out on the face with a square recess so that the column is held by the corners of the jaws on each side of the parting line of the casting. The machinist turning the columns also operates this machine "between cuts" and thus keeps himself supplied with accurately centered columns. The lathe mostly used for turning these columns can be seen behind the centering machine and is a special tool designed for this particular work.

One of the minor schemes for reducing manufacturing cost on small parts, which is quite typical of the general practice, is quite clearly indicated in Fig. 7. This shows the method of casting and machining the brackets for the table elevating screws and also the table nuts. The pattern is made so that six pieces are cast at once and in this shape they go through the necessary machining operations until finished, when they are cut apart along the dotted lines E E, etc. Thus, the first operation is boring and also facing the ring in the case of the table nuts, the latter being so made as to allow the table to swivel around the column. The casting for the upper brackets shown in Fig. 7 is then centered in a jig for turning the ends B B B, etc., in a lathe, these being turned to give a bearing to the bevel gear carrying the crank handle. The holes C C C, etc., for the elevating screws, are then drilled in a jig as are also the holes through the side for the holding screws, as indicated at D D. The casting is then cut apart, resulting in six complete brackets in this case, and in six complete nuts when the casting for the table nuts is the one in question. The latter is not made with the projecting part B B B, etc., so does not require turning, but instead has to be tapped for the elevating screw.

All elevating and similar screws are made from a good quality of steel containing a considerable percentage of carbon, and are turned and threaded in an engine lathe. Cold-rolled steel is not used for any purpose in either lathes or drillers. All small pinions are made integral with their shafts from stock forged roughly to shape.

The 13" sensitive drillers are built with one, two, three or four spindles, so that the upper part of each is a separate casting from the base. The upper parts are first planed on the vertical ways for the sliding head and then are planed on the ends, while held in the jig, Fig. 8. This jig, shown in plan and elevation, is made to hold six short columns, one of which is the pattern or dummy and the other five the ones to be machined. The columns are held by the dovetailed ways engaged in the grooves, A A A, etc., being firmly secured by the loose pieces B B B, etc., which are held to the jig by the screw bolts shown. The pattern, G, shown in place, gives the planer hand the guide for exact reproduction by simply setting the tool at the planed surfaces E and D. It is quite common to see these patterns, where the system of producing duplicate parts in this manner is followed, gouged and cut by the planer tool, due to accidents or carelessness of the planer hand. Not so here; the pattern in question has been in use for a number of years and to all appearances is as good as new. The same condition was noted in regard to the patterns used on the planers devoted to planing lathe beds, showing that the machinists and apprentices employed are a very careful and painstaking lot of men. One of Mr. Vernon Prentice's characteristics is his faith in his "boys" as he familiarly calls those in his employ and apparently his confidence is well founded.

One of the good points of Prentice drills is the quiet running

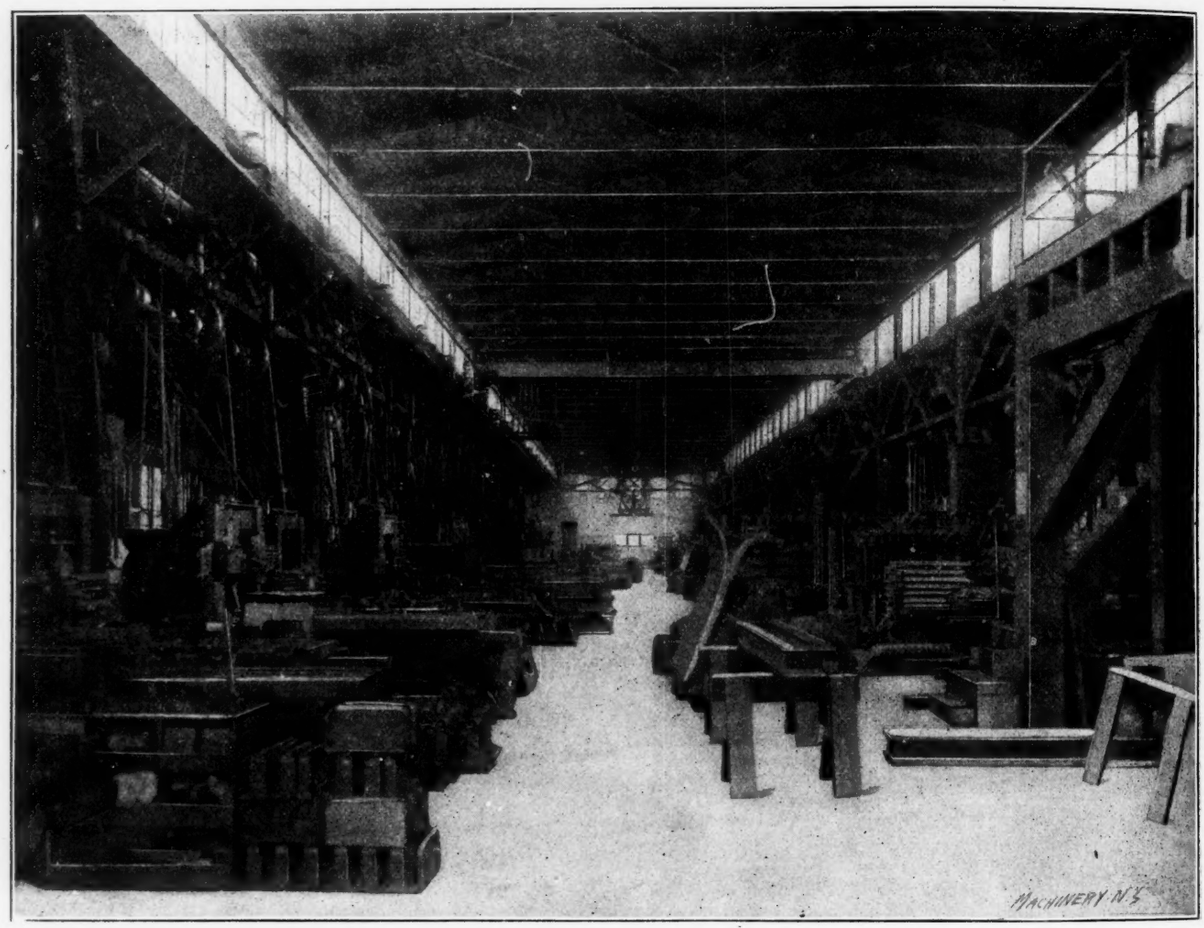


Fig. 2. Main Erecting Floor, Looking South.

Fig. 3. Under Gallery, Main Floor.
Fig. 4. Lathe Erecting Room, West Annex.

Fig. 5. View on Main Floor Showing Column Centering Machine.
Fig. 6. View in East Annex Showing Turret Department.

of the gearing, especially the bevel gearing. No pains are spared in securing this desirable result. The larger gears for the radial drillers are generally planed, giving an octoid tooth curve. The smaller bevels are cut with milling cutters, a number of gear cutters for this work alone being provided, among which was noted a new Brown & Sharpe, of the latest pattern.

All spindles and shafts of both drillers and lathes are made

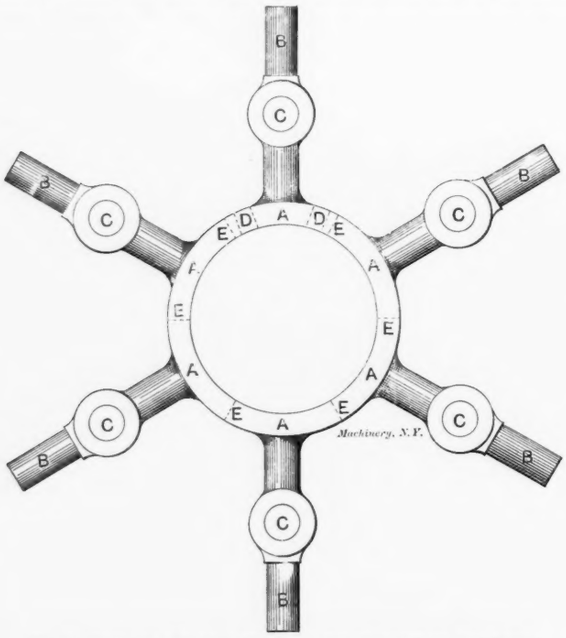


Fig. 7. Method of Making Elevating Screw Brackets and Nuts.

from high-grade steel, all being ground to exact gage on the grinding machines. Not a shaft or spindle is filed and the use of emery cloth for polishing such work, is strictly prohibited. All shafts and spindles are put into the machines showing the distinct cuts of the emery wheel, which, to the well-informed purchaser, are the best sort of a guarantee of their circularity and general accuracy.

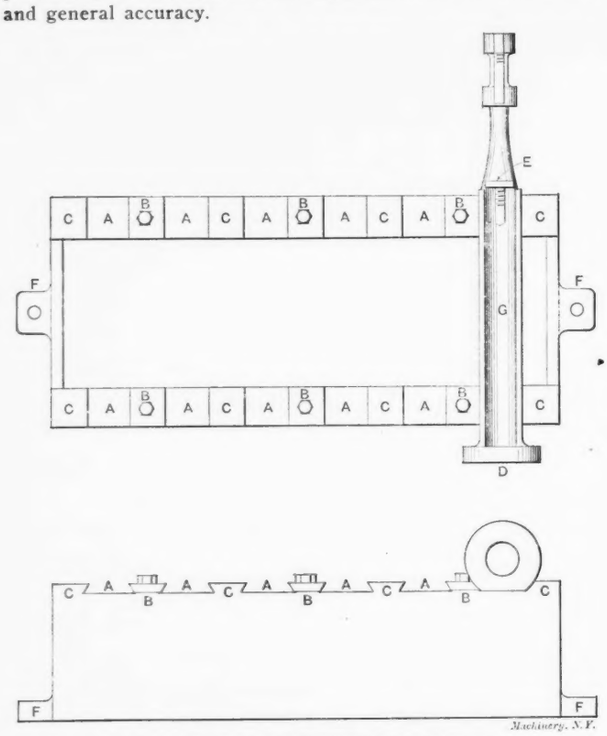


Fig. 8. Jig for Planing Sensitive Driller Columns.

Milling operations are extensively followed for the production of plane surfaces. In the case of slide rests and similar parts requiring to be accurately scraped and fitted, it is the custom to first rough mill the parts and then to plane them to size. In this manner, the warp and twist due to the milling operation, is removed and the surface left in good condition for scraping and fitting. A Becker-Brainard vertical miller is used on the heavier work, one job noticed being the facing off of the bases for the bottoms of the columns used on some forms of the drillers. The bases were first bored on a Gisholt turret lathe, the base being held by the flanged portion shown at D in Fig. 9. Each base is bored and faced off at the upper end so that they are all of approximately the same length. They are then mounted on the jig shown in Fig. 9 at A, three at a time. The jig has the three bosses, B B B, which are split with a milling cutter with two cuts at right angles and provided with the threaded taper plugs, C C C, having squares at their upper ends for a socket wrench. The castings for the bases being set over these bosses, are firmly held by expanding the latter by screwing in the taper plugs. Holes are bored through the bosses, as indicated at E, to give the quarter parts more elasticity. The cuts made by the circular cutter when quartering the bosses, are filled in with thin strips of pine wood to prevent the entrance of chips into the openings which would give trouble by wedging them so that the parts would not spring together when the taper screw is released. By having the milling cutter operating on the bases arranged in a series, as shown, there is a distinct gain in time of operation as compared to that required for them when done singly. The cutter used, shown in Fig. 10 is about 10¼″ across the center of the teeth, which thus enables the cutter to sweep the entire surface of the 10″

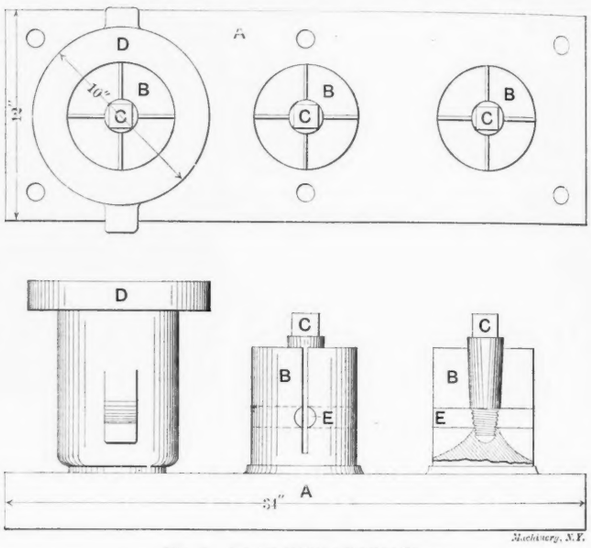


Fig. 9. Jig for Milling Driller Bases.

base at one cut. If only one base were operated on, the table carrying the base must travel about 22″, provided the entire cutter sweeps the surface which is desirable. With three mounted in a series, the table only has to travel about 43″ in order to sweep the entire surface with the full diameter of the cutter. There is also no time lost in chucking, as the finished parts are removed and replaced by others as fast as the cutter passes over them, the table being reversed in direction of feed at the end of its travel.

The cutter shown, is one made especially for this work and is a simple tool, easily made and possessing a number of features of merit. The body, A, is made of cast-iron, turned all over and threaded to screw on to the spindle. It is drilled on a 10¼″ circle, with 18 holes ⅝″ in diameter for the reception of the Mushet steel cutters made from round stock. The cutters are held from backing out by blind screws, one being shown at B and sideways by similar screws as at C. The combination is neat, not costly in construction and effective in operation.

In the department with the milling machine just referred to are the Gisholt lathes and a new American turret machine, which is very favorably regarded by those having it to operate as well as those directly interested in its products. The feature of power feed for the turret, together with that of automatic turning of same, saves the operator from what would otherwise be a man-killing job, on such a heavy tool. The use of the turret machines has effected some radical changes in cost of production, the writer being shown one piece formerly costing

20 cents when made by the piece on an engine lathe, which now costs only 4 cents when made on the turret lathe. When splining drill spindles, the practice is followed of doing them in gangs. A jig, being little more than a false table, is provided

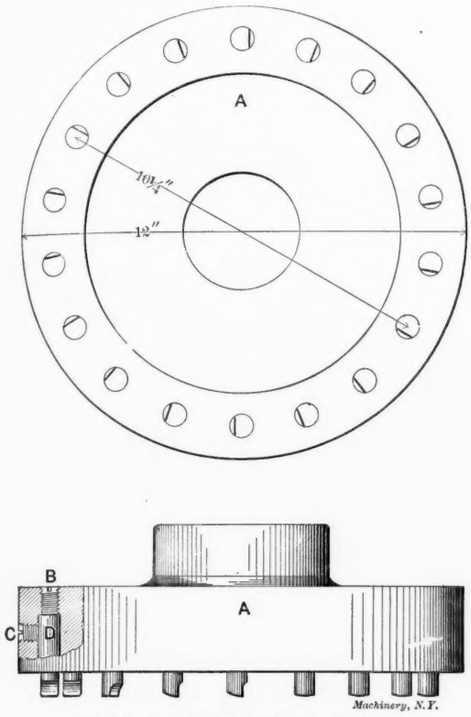


Fig. 10. Inserted Tooth Milling Cutter.

for the milling machine platen with four grooves or Vs, planed longitudinally. In these grooves four spindles are laid at a time and held by short clamps and stud bolts. The milling machine arbor carries four cutters set the right distance apart to spline each shaft radially.

The Manufacture of Lathes.

The making of lathes, while less in importance as far as numbers to the manufacture of the drilling machines is, however, with this firm, carried out with the utmost thoroughness and many special arrangements have been made to lessen cost of production and insure accuracy of product.

The spindles are first drilled for the through hole and then are turned and ground without the insertion of the usual plugs

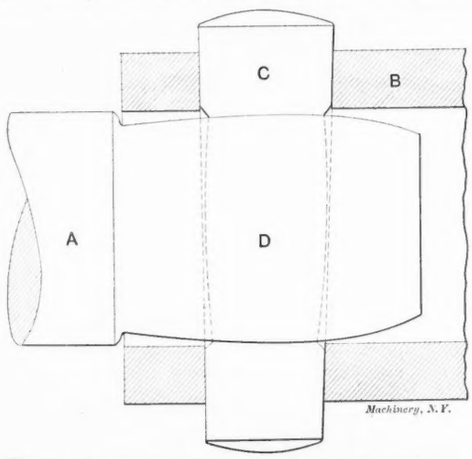


Fig. 11. "Floating" Reamer Connection to Drill Spindle.

for centers, the ends of the center hole being carefully reamed concentric and to about a 45° angle, making a seat for the lathe and grinder centers about ⅛" wide. The spindles are ground after being keyseated for the face gear and then the gear is set. The boring of the taper hole is reserved for the last operation when everything has been done which might in any way disturb the perfect alignment of the bearings, as for instance the fitting on of the face gear. The spindles run in hard bronze boxes which are turned and bored before being inserted in the headstock and afterwards bored and reamed. The bronze castings are first milled on the joint and then clamped together for the rough boring. After being bored, they are clamped on a mandrel and turned about one or two thousandths large for the bored hole in the headstock. The lower half of each box is forced into its seat, then drilled for two screws for holding it firmly in position. The countersunk holes for the screw heads are filled in with babbitt, making a smooth surface. The upper part of the box is secured to the cap in the same manner.

The headstocks are first planed and then drilled and bored for the various holes while held in a box-like jig shown in Fig. 12. The headstock is held to two Vs on the inner side by four hook bolts engaged over the projections of the headstock holding in approximately the same manner as when finally erected. In this position the holes are drilled and bored under the driller shown back of the jig. Hardened steel bushings are provided for the various boring bars shown leaning

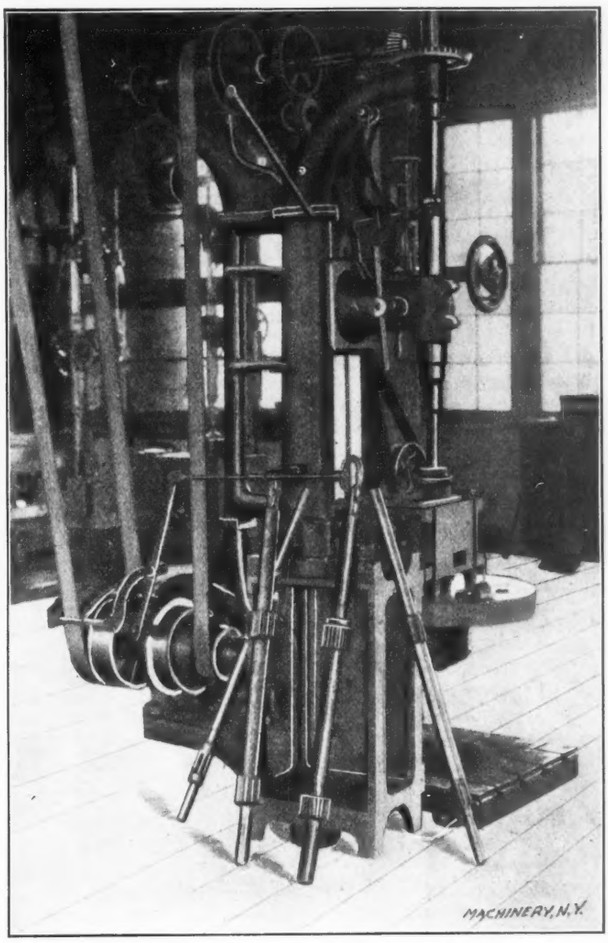


Fig. 12. Jig for Boring and Reaming Lathe Headstocks, with the Driller on which they are Done.

against the jig. The headstock is first rough bored by hog-nosed cutters and then reamed by expansion reamers, after which the bronze boxes are fitted in, as already described, and then these are also bored and reamed. The illustration shows the two sets of roughing and finishing tools leaning against the jig. The hole for the back gear shaft is bored and reamed after the bronze boxes are bored and finished so that the center distance must come exact. The boring bars are fitted into the driller spindle by a species of universal joint which allows the bar to be entirely controlled by the bushings in the jig and prevents any binding or springing. This is illustrated in Fig. 11, the end of the bar being represented by A, which is turned to about the shape shown at D. The key, C, is of rounded outline, as shown by the dotted lines. The bar is thus free to swing by a limited movement, the key only serving to drive it.

A special 16′ lathe is made with hardened spindle and with a "flat-footed" headstock or one not having V-grooves for the

Vs ordinarily provided for holding the headstock in alignment. The headstock in this lathe is held at the rear by a bolt on which it is free to swing sideways to bring the alignment correct. To preserve the correct position, two screws, B B in Fig. 13, are tapped in the piece C, fastened to the lower side of the headstock A, against the sides of the shears. In this manner the headstock is easily aligned and if in after years corrections for alignment become necessary, it can be done without refitting on Vs or changing the boxes. The holding bolts for the headstock on this style reach down to the under side of the bed, being indicated by D D.

The method of hardening the spindle of this lathe is interesting. After it has been drilled and roughed out, it is copper-plated by electro deposition and then the bearings, which are the only parts to be hardened, are polished bright. The spindle is then put in a case-hardening furnace packed in the usual manner and afterwards dipped. The steel used being about .20 carbon, only hardens where the bearings are polished, the other parts remaining soft enough, where protected from the

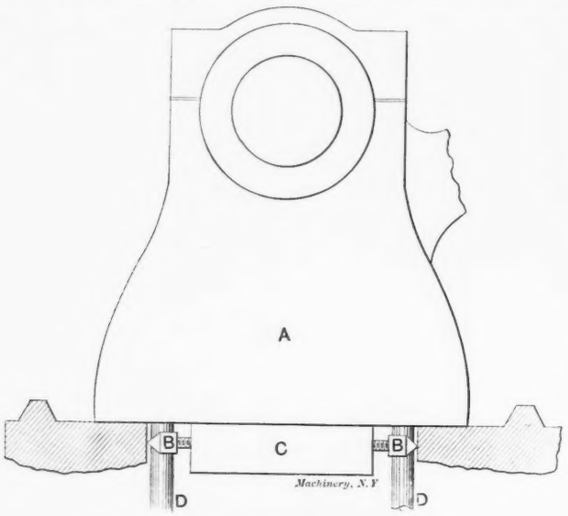


Fig. 13. "Flat-footed" Lathe Headstock.

action of the bone dust by the copper-plating, to allow the thread on the nose to be cut and the taper hole to be bored after the grinding operation. A spindle made in this manner seems almost ideal, as it is hard where needed but not throughout, so that no danger from breakage need be apprehended.

The expansion reamers referred to in connnection with boring and reaming the headstock are typical of the practice throughout the shop, expansion reamers and taps being generally used The writer was shown one for reaming headstocks recently designed, which has a range of expansion of 3/8" and adjustable by the minutest increments. The expansion taps referred to have been found valuable in preserving the interchangeability of tapped holes of the larger sizes. The usual plan in making these taps is to have the cutters in three parts, some having two, and others three rows of teeth for each cutter, making in the first instance six rows of teeth and in the second case nine rows of teeth.

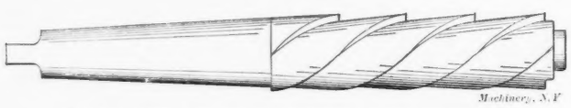


Fig. 14. Milling Cutter for Machining Tool-post Slots.

In the making of small tools for various uses, considerable ingenuity and skill has been displayed. Some of the tools in daily use date from the organization of the company and are to-day doing very good work. One of the schemes in using the milling machine for slotting is illustrated in Fig. 14. The holes for a slot like that in a tool post, are drilled in the ordinary manner and after the slot is roughed out it is finished by the spiral cutter or reamer shown by traversing the table holding the piece. In this manner the slots are smoothly and quickly finished.

The methods followed in testing lathes after erection, are substantially the same as those generally employed by machine tool builders, narrow limits of allowable variation being established and readings being taken by Bath indicators. Such is the care bestowed on the preliminary work, that very little refitting is ever found necessary when testing. A lot of, say, twenty-five lathes will go through the final tests with the result that possibly one or two will require some slight changes

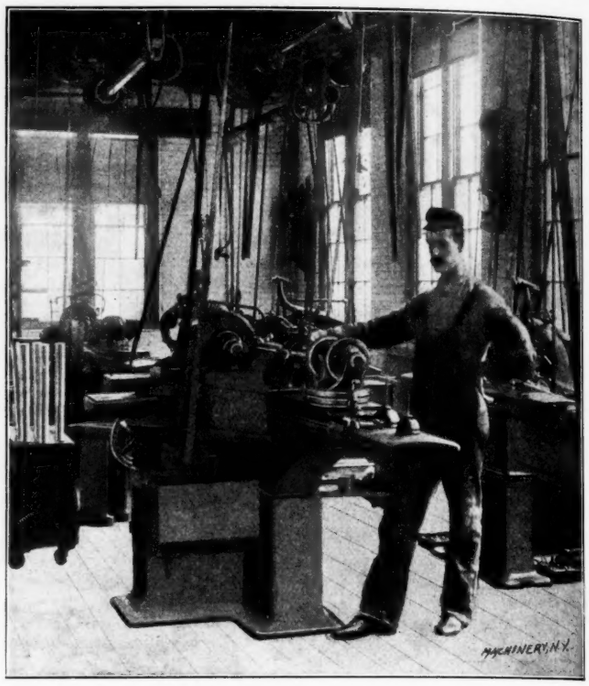


Fig. 15. Corner of Grinding Department.

to meet the test requirements. These exceptions are often due to the slight molecular changes that take place in castings especially after being machined, and are never the same in any two, some showing considerable change of form after being allowed to lie after machining and others not changing perceptibly.

* * *

As an illustration of the effect of the inertia in preventing the smallest masses being instantly moved, the experience acquired in England by the Ordnance board in registering the velocity of flight of projectiles, is interesting. For measuring the velocity of projectiles fired from rifled cannon using the old slow burning powders and giving initial velocities of about 1,500 feet per second, it was the practice to have triggers set along the bore at intervals, to be successively knocked down when the projectile was fired. The difference in time between the various triggers as registered by a chronograph, gave the acceleration and the final velocity at the muzzle. On the advent of the high-power, smokeless powder the old arrangement was found to be unreliable, as the increased velocity of the projectile, 2,500 feet per second, often had the effect of not knocking down the triggers on first impact, their inertia being so great that instead they would plow a groove through the side of the shot and remain unmoved for such a period of time as to make their final action entirely untrustworthy.

* * *

On October 24th, Dr. Henry S. Pritchett, former chief of the United States Coast and Geodetic Survey, was inaugurated president of the Massachusetts Institute of Technology, and there is every reason to believe that the advent of his presidency will cause even greater prosperity to this institution than it has shared in the many years of its successful existence. A distinguished company was present at the inauguration, consisting of representatives of colleges and universities from all parts of the country and of representatives of the alumni organizations, the entire main body of the hall being filled by the students, 1,250 or more in number. Dr. Pritchett's practical experience as director of perhaps the most important purely scientific branch of the Government service rendered his inaugural address upon "The Relation of Educated Men to the State" peculiarly suggestive.

AUTOMOBILE VEHICLES*.

SUMMARY OF THE FEATURES OF THE VARIOUS SYSTEMS IN USE.

LOUIS DERR.

The problem confronting the automobile builder is to apply to the frame of a road vehicle a motor of sufficient power and endurance, under absolute and quick control and free from liability to accident or failure. It should be simple, easy of repair and capable of satisfactory operation without technical training on the part of the driver. Renewals of energy should be readily obtainable, and at a moderate cost. But the attempt to solve, even approximately, the problem stated in these requirements is a matter of extreme difficulty, and a complete solution cannot yet fairly be said to have been found.

Existing types of motive power may be classified as follows:

1. Electric motors.
2. Internal combustion engines.
3. Engines driven by a gaseous pressure, including (a) steam engines and (b) vaporization engines, utilizing hot water under pressure and liquefied gases.
4. Combination types, usually an electric motor and internal combustion engine. Not very successful.

The Electric Motor.

The electric motor, as applied to automobiles, presents virtually the problem that has already been solved for the street railway, and is now a very satisfactory piece of apparatus. It is usually of the four-pole enclosed type, series-wound, of high ratio of copper to iron and of great overload capacity. The motor is driven by current from a battery of 40 to 44 coils for the usual conditions of charging from a 110-volt circuit. The speed control is partly by dividing the battery electro-motive force into halves or quarters, and partly by varying the strength of the motor fields. Either one or two motors may be used, and no starting rheostat is necessary.

The chief objections to the electric vehicle arise from the storage battery. After forty years of experimenting, the best types of battery for vehicles are now made of the "formed" type, just as were Planté's cells in 1860. The layer of active material on the surface of the positive plates is formed by repeated charging and discharging, instead of the shorter process of "pasting" on the plates a lead salt which is then changed to the active peroxide by a single charging. The latter type is cheaper, but, under severe usage, fails rapidly. The most efficient batteries give an output of 3.5 to 6 watt hours per pound—from 125 to 213 pounds of battery per horse-power hour; but, as this weight is prohibitive, a lighter and less durable battery is used. The Columbia batteries give 3.8 ampere-hours per pound, or about 8 watt-hours. Batteries have been built claiming 10 or more watt-hours per pound, but they are probably of very short life. The average efficiency of batteries in automobile service is low, and the depreciation very high. A series of tests instituted by the Automobile Club of France showed an average efficiency of only 62 per cent., and of the eighteen batteries entering the competition only eight survived the sixtieth discharge.

The advantage of the electric vehicle is its simplicity and ease of operation; it would be difficult to devise anything simpler than the controller handle. A minimum of noise, no smoke or odors and immediate availability of the power complete the list of desirable qualities. But the weight and expense are serious matters. Energy for propulsion may be taken as averaging 120 watt-hours per ton-mile for good roads, and the battery furnishes about half of the total weight; whence the minimum battery for a given radius may be quickly calculated. The great weight is destructive to pneumatic tires, and is with difficulty hauled over grades. Since the motors are series-wound, there is no way of recovering even a fraction of the energy expended in climbing a grade by recharging the batteries during the downhill run. The disadvantages are therefore expense of maintenance and high first cost, as well as limited radius of travel unless suitable recharging stations can be found along the route. It is only fair to say, however, that the cost of battery renewals in one case is given as three-quarters of a cent per mile, and the cost of charging current 1¾ cent.

* From the Journal of the Association of Engineering Societies.

The Internal Combustion Motor.

The internal combustion engine for automobiles has been highly developed in France, but as yet has not found extended favor in this country. In this type of motor the propelling impulses are furnished by the very rapid combustion or "explosion" of a mixture of hydrocarbon vapor and air in a cylinder behind a piston. Since there is no way of protecting the piston rod and glands from the intense heat of the combustion, such engines are necessarily single-acting from the opposite side of the piston. The cycle of operations is as follows: A forward stroke draws into the cylinder a quantity of the explosive mixture, and on the return stroke the charge is compressed. At or near the end of the stroke the mixture is ignited, and the pressure developed by the explosion drives the piston through the second forward stroke. At the end of the stroke the exhaust valve opens, and the burnt gases are pushed out of the cylinder on the second return stroke.

There is thus but one working stroke in four during the above or Otto cycle, and the engine must therefore be larger than one of the same power in which each stroke is a working stroke, as in the steam engine. The shock accompanying the explosion requires a more substantial construction than would otherwise be necessary, and the high speed at which such motors must be run to develop sufficient power in small weights renders careful balancing imperative to prevent excessive vibration. In small sizes the cylinder may be kept sufficiently cool by providing it with projecting ribs to increase its radiating surface, but in engines of over 4 horse power a water jacket is necessary. The water is in turn cooled by circulation through a cooler composed of ribbed tubes and exposed to a draft of air.

The original open-flame method of igniting the charge has been superseded by the hot tube method, and this in turn is being displaced by the electric spark. The former method requires a tube of nickel or other refractory material, closed at the outer end and heated to dull redness by a flame. The open end of the tube communicates with the cylinder, and the heat ignites the compressed charge. This has proved somewhat unreliable, and at present most engines are ignited by an electric spark. This is produced by an induction coil or similar apparatus, the spark points consisting of a pair of platinum wires projecting through an insulating plug into the cylinder.

The objections to the explosion motor for automobile service are its complexity and—thus far at least—its unreliability. The latter is almost wholly due to the ignition apparatus, and it is interesting to note that both methods of ignition are now used on French racing carriages. The motor is not self-starting, and a special starting gear must be provided. The same is true for changing speeds and backing, both of which are usually accomplished by gear trains, although belt transmission is also used. The vibration of the engine is also a difficulty not easily overcome. Minor causes for criticism are the loud noise of the exhaust, even when a muffler is used, and the odor which is left for some time in the track of the machine. On the other hand, the speed and endurance of vehicles of this type far surpass anything that has as yet been obtained by other constructions, and they are therefore pre-eminently fitted for racing and long runs. A tricycle fitted with a motor of this type has covered 45 miles within the hour, portions of the distance at speeds greater than 60 miles per hour; and the limit seems to be only in the physical endurance of the rider and the heating of the pneumatic tires.

The Steam Engine.

As might be expected from the time during which the steam engine has been a practicable prime mover, the steam-driven automobile has a lengthy history. In 1769 Jean Francis Cugnot built a steam-propelled gun carriage, using an internally fired kettle-shaped boiler and an engine connected to the driving wheels by a ratchet and pawl mechanism. Development was very slow, however, and in England was entirely stopped by restrictive legislation and in America by the absence of good roads. The removal of legislative restraints in the one country and the appearance of satisfactory highways in the other have greatly stimulated invention, and the result is a considerable number of steam vehicles both for light and heavy service.

The steam carriage for pleasure may be best discussed by describing a type now extensively exploited in this country.* This

* The Locomobile.

carriage has a small upright fire tube boiler, holding six or seven gallons of water and weighing about 100 pounds. The fuel is gasoline, stored under air pressure in a supply tank. After vaporization by passing through heated tubes it is blown through a burner, taking up in its passage air enough to insure proper combustion. Automatic arrangements shut down the fire when the steam pressure reaches the predetermined limit. The engine is double, of the marine type and is connected to the driving wheels by a chain gear.

The small size of the reciprocating parts renders the engine vibration insignificant, and the carriage makes but little noise. A further advantage is its lightness, a carriage for two persons weighing, when fully equipped, only about 600 pounds. Its endurance depends, of course, on the size of the fuel and water tanks, but may be set as 20 or 30 miles for one filling. The great advantage of motors using naphtha or gasoline over storage batteries is that a new supply requires only a few minutes' time, and is readily obtainable. Low first cost, small operating expense and comparative simplicity of construction are further items that have contributed much to its popularity.

The steam carriage, however, is by no means free from objections. In starting or after long stops time is required to raise steam, and on the road a considerable fire is burning, supplied by the most inflammable fuel under pressure. This is a source of possible danger that should not be forgotten. The small size of the boiler and its very great steaming capacity make a frequent inspection of the water-glass an essential part of the driver's duties; and in general it may be said that the steam carriage requires more care on the road than any of the types previously described. A minor objection is the visible exhaust in cold weather. Apparatus for condensation, if effective, is too cumbrous to be satisfactory.

The small size and method of construction of the boiler render accident from explosion unlikely, but the water level must be rather closely watched to prevent burning the tubes by the intense fire. A type of boiler is coming into use known as the "flash boiler," in which there is very little water, only as much being injected as is required by the engine, stroke by stroke. This boiler, developed by Serpollet in France, and commonly known by his name, consists of a series of tubes of very narrow cross-section, heated to a high temperature by the furnace gases. The tubes vaporize the water almost instantly, and can be heated red hot without injury. It is evident that the water supply must be automatic and exactly proportionate to the consumption of steam. This requires reliable feeding devices. The tubes are short-lived but inexpensive, and their thickness, combined with the small amount of water in the boiler, makes explosion practically impossible.

Compressed Air.

Compressed air has been the engineer's dream ever since the invention of the steam engine, and many attempts—for the most part futile—have been made to apply it to vehicle propulsion. The chief trouble is from the inevitable refrigeration accompanying expansion, which, without reheating devices, quickly clogs the exhaust passages with frost; but, even apart from this, the energy stored in compressed air is really comparatively small. It can be shown by a simple calculation that a pound of air, expanding isothermally from 150 pounds gage pressure to 15 (11 atmospheres to 2), will develop 48,300 foot pounds of work. Assuming that the steam carriage already described will develop 2½ horse power hours before exhaustion of water supply, it follows that 103 pounds of air will be needed for the same endurance under the given conditions, which, by the way, are beyond the possibility of realization in practice. At the given pressure the air would occupy 122 cubic feet, and a tank nearly 5 feet cube would be needed. As this is out of the question, a much higher compression is used, and the customary pressure is 2,200 pounds or about 150 atmospheres. This reduces the volume to 9 cubic feet. Steel reservoirs to withstand this pressure weigh about 85 pounds per cubic foot of capacity. A weight of 66 pounds has been realized, but in this case the factor of safety is rather small, and explosion of a tank under this pressure is highly dangerous. Thus to contain the air 765 pounds of reservoir will be needed. To have 165 pounds pressure at the end of the run another pound of air will be required, making a total of 869 pounds for reservoir and contents. This may be instructively compared with the 240 or 250 pounds required by the steam carriage for fuel, water and boiler. The weight of engines and piping is assumed to be the same in the two cases.

In practice the case is not quite as favorable for the air engine. Available data indicate that by using compounding, reheaters, etc.,—all adding weight and complication—about 0.27 of a horse-power hour can be obtained from a cubic foot of air at 2,000 pounds pressure. This weighs nearly 11 pounds, whence to get 2½ horse-power hours 118 pounds of air will be required. In the table below the available energy of compressed air expanding without loss under different pressure conditions is given for the sake of comparison with other sources of power.

Liquid Air.

In this connection it may not be out of place to call attention to the ludicrous claims put forward for the energy available when liquid air is vaporized. Of course the only reason for employing liquid air is the fancied possibility it offers of carrying the equivalent of a large amount of gaseous air without pressure. By noting that about 800 volumes of free air are required to produce one volume of liquid air, the energy of a pound of the liquid may be easily calculated. If vaporized in a closed tank the pressure would rise to 800 atmospheres, or, roughly, 12,000 pounds per square inch. Assuming that the total energy can be realized in isothermal expansion, there would still be demanded 10.5 pounds of liquid per horse-power hour, or, in other words, a gallon of liquid air represents a maximum of only three-quarters of a horse-power hour, an amount by no means difficult of comprehension.

Recapitulation.

The following table presents at a glance the previous results, and shows clearly the reason for the extraordinary endurance of the internal combustion engine:

	Foot Pounds per Pound of Medium.	Pounds per Horse Power Hour.
Light storage battery	15,000	132
Steam in small engine	49,500	40
Air expanding isothermally from 165 to 30 pounds	48,300	41
Air expanding isothermally from 165 to 15 pounds	69,400	28.6
Air expanding isothermally from 2,200 to 15 pounds	137,000	14.4
Air expanding isothermally from 12,000 to 15 pounds	188,000	10.5
Air in perfect air engine, 165 to 15 pounds	48,700	40.7
Air in perfect air engine, 165 to 30 pounds	37,600	52.7
Air in perfect air engine, 2,200 to 15 pounds	74,400	26.8
Coal, 14,500 B. T. U., in steam plant of 12½ per cent. total efficiency	1,410,000	1.40
Kerosene, 20,700 B. T. U., in internal combustion engine of 35 per cent. efficiency	5,590,000	0.354

The question of cost of maintenance, always an interesting one, has not yet been definitely settled for American conditions. The following table is for a carriage belonging to a French physician, and covers an experience of 6,000 kilometers (about 4,000 miles). It undoubtedly represents a fair average cost. Although in this country the fuel and lubrication cost would probably be smaller, and the writer's experience would incline him to reverse the proportion of repair and depreciation charges, the greater cost of tires for American roads would probably keep the total about the same. Of course, if the carriage is cared for by the owner the last item disappears:

Gasoline	2.00 cents per mile.
Oil and grease	0.15
Tires	0.94
Repairs and miscellaneous	5.05
Depreciation	3.09
Interest and taxes	1.09
Hostler	4.67
	16.99

In conclusion, it may fairly be said that the choice of type depends almost wholly on the character of the service. For urban passenger service, where recharging stations are conveniently accessible and frequent stops are necessary, the electric vehicle will probably hold its present supremacy for some time. For heavy service the steam car seems to be the most successful, and for high speeds and long runs the internal combustion motor at present shows a decided superiority over its less costly rival, the steam engine.

A COUPLE OF MECHANICAL PARADOXES.

PRACTICAL APPLICATIONS OF PECULIAR MECHANICAL PRINCIPLES.

C. C. STUTZ.

According to Webster's definition a paradox is "A tenet seemingly absurd, yet true." Using this explanation as a preface, I wish to introduce and prove to the reader the following facts: It is not only possible, but commercially feasible

1. To cut a thread on a bolt or similar piece by means of a tap.

2. To cut a thread in a right-hand nut by means of a left-hand tap, or vice versa.

There are many well-known ways of producing a screw thread on a bolt or in a nut, such as chasing with hand tools, cutting in a lathe, milling on a universal or special milling machine, or by means of die and tap, either by hand or in a screw machine. To these different methods of doing the same thing, I would like to add another, which I hope will prove interesting.

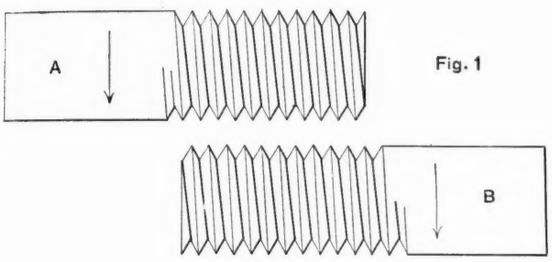


Fig. 1

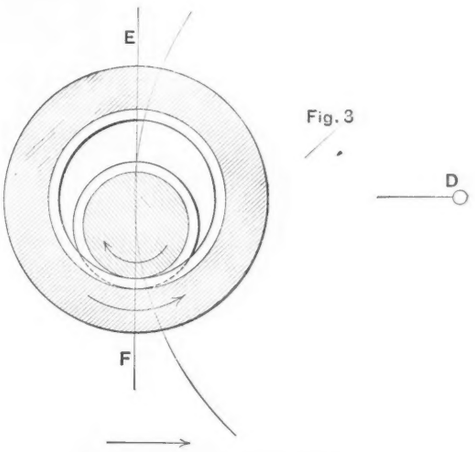


Fig. 3

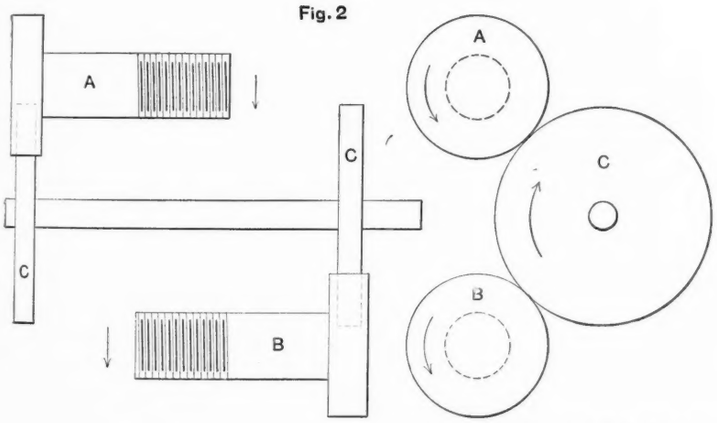


Fig. 2

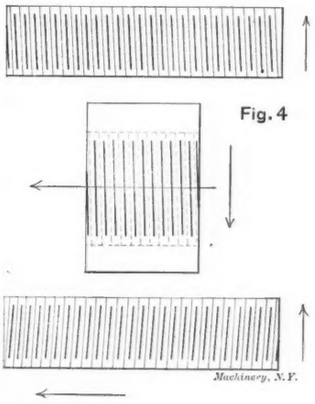


Fig. 4

Illustrating Principles of Thread Cutting.

Several years ago a machinist related in one of our well-known technical papers a very peculiar experience he had had. It seems that in tapping a hole in a piece of cast iron with a right-hand tap he found that, on having finished his job, the screw intended for it would not fit the thread; and upon close examination he found that instead of a right-hand thread he had a left-hand one. In trying the tap again in other holes he could not repeat his experience. Now this man wanted an explanation of why his tap had behaved so oddly. The letters which were written in reply to his query developed the fact that others had had similar experiences, but the explanations offered did not seem to "explain." Like a good many others, I smilingly read the correspondence and finally dismissed the subject as simply "absurd." Some time after, while traveling in the interior of Russia, I was shown, in a machine shop, a rather crudely designed and not well executed device which at once recalled to me the above-mentioned articles. Sure enough! here was a man who was cutting a right-hand thread in nuts with a left-hand tap, and he was doing it every time, and doing it well, considering the construction of the device. And what is more, he was beating at the rate of four and five to one a specially designed and well-built thread milling machine made by a well-known American house.

I will try to explain this seeming impossibility. To do so let us turn to the first mentioned paradox, namely, the cutting of a thread on a bolt or similar piece by means of a tap. Let the reader take two bolts of the same size with right-hand thread of the same pitch cut on them and place them on the table side by side, as shown in Fig. 1. It is very evident that if we place them still closer, so that they touch, the threads of one bolt will fit in the spaces of the other, and this along the whole length of the thread. This will be the case for two reasons. In the first place the shape of the threads in both bolts is the same. The other reason we find in the fact that the bolts have both the same kind of thread and the same pitch. This latter point is of importance and means that a tangent to the helix of one bolt at the pitch line of the thread, and at the point where it touches the other bolt, is also a tangent for this latter one. This means that this tangent is common to both bolts. This being the case, it will now readily be seen that if we revolve the two bolts around their axis in the same direction as indicated by the arrows in Fig. 1, the bolts will retain their relative positions towards each other and the threads will still perfectly engage, provided only that we revolve the two bolts at the same speed. This object can be attained by gearing them together, as shown in Fig. 2. On a common shaft two gears, C, of the same size, are mounted and keyed; to each bolt is keyed a gear A and B respectively, A and B being of the same size. If, now, the shaft carrying gears C is revolved, the bolts A and B will revolve in the same direction. Now supposing:

a. That bolt A is replaced by a blank stud (without thread).

b. That in the place of bolt B we put a tap.

c. That we arrange our rig in such a manner that we can approach B to A by rolling their respective gears over gears C.

Then we find that as soon as the tap B comes in contact with the blank A, there will begin a simple milling operation, the only difference being that the piece operated upon, instead of being stationary, will revolve at the same speed as the cutter or tap.

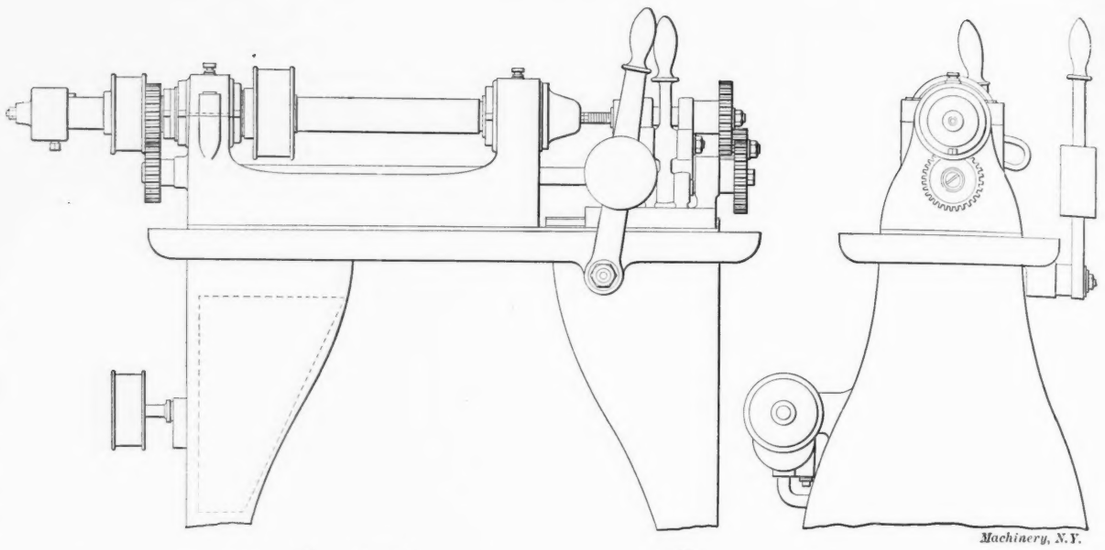


Fig. 5

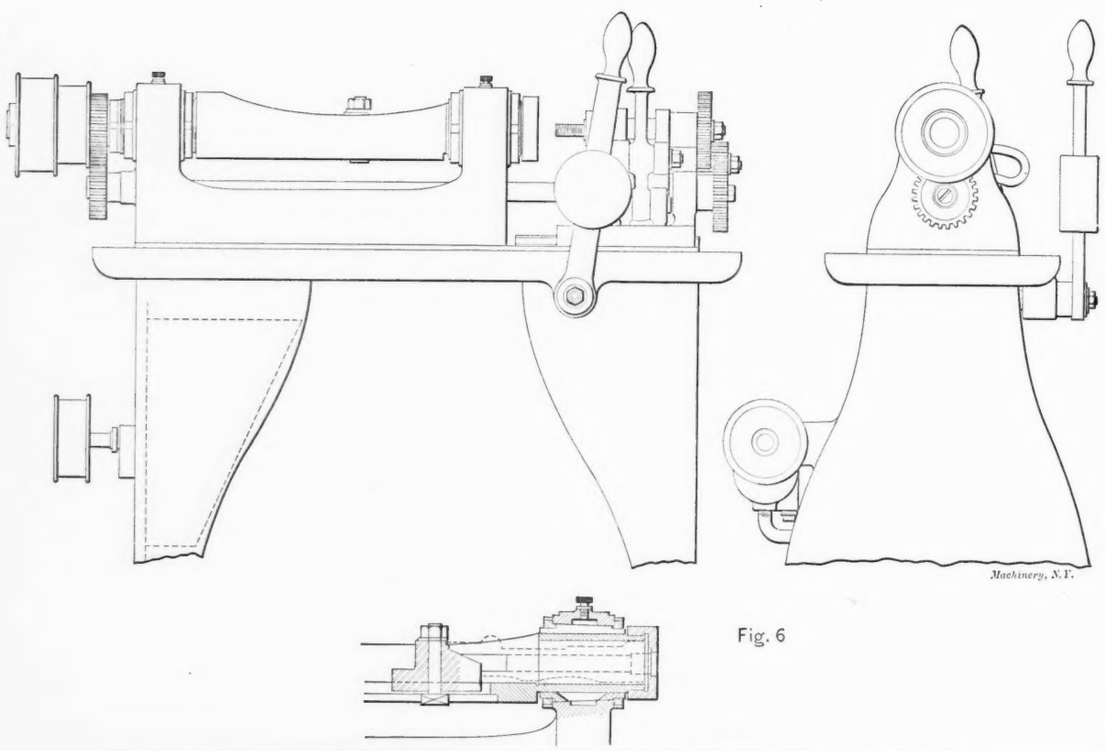


Fig. 6

Elevations and Details of Machines Designed for Cutting Threads by the Principles Illustrated in Figs. 1 to 4.

Thus I believe to have made good my assertion that it is possible to cut a thread on a bolt or similar piece by means of a tap.

In practice I have found that an ordinary tap does not very well answer for smooth and quick work. Upon reflection we will readily see that a tap with four deep flutes, as is usual, has not sufficient teeth to perform the operation well. It is therefore advisable to make a cutting tool with as many flutes as possible. The flutes need not be deep, hardly going below the depth of the thread. The reason for this is apparent. In our case the chips easily get out of the way, while when a tap is used to cut threads in a nut, provision has to be made to store them, so to speak, till the tap can be removed. I have found that 20% variation in the diameters of A and B still produces a very good thread. It is remarkable how rapidly a thread is produced in this manner; a few revolutions, and the thing is done.

I will now attempt to explain my second statement which is to the effect that it is possible to cut a thread in a right-hand nut by means of a left-hand tap, or vice versa. Although this explanation is simple, especially in the light of what has already been said, yet I would caution the reader to follow very carefully every step. In the first place the method employed is here the same as in the previous case, and it differs from the usual methods inasmuch as all the threads in the nut are attacked at the same time instead of giving the tool or tap a progressive motion along the axis of the nut. To do so it is very evident that the outside diameter of the tap must be quite a little smaller than the tap-hole of the nut. Fig. 3 shows a bolt placed in the threads of a larger nut. In order that the threads of bolt and nut engage, it is, of course, necessary that both have the same pitch. Referring to Figs. 1 and 2, we have found that in order to obtain a

cutting action between bolt and tap, they must be revolved against each, or in the same sense of rotation (due to the fact that they touch outside to outside). Now in order to obtain a cutting action with tap and nut, the two must revolve in opposite directions as indicated by arrows in Fig. 3. Furthermore, the ratio of rotation in this case must again be one to one; for, the pitch being the same in both pieces, only under this condition will the threads keep in mesh. Recapitulating the conditions imposed by the problem we find that:

1. The tap must be smaller than the tap-hole of the nut.
2. The two pieces must rotate in opposite directions.
3. The ratio of motion must be 1 to 1.
4. The pitch in nut and tap must be the same.
5. The threads must keep in mesh, i. e., the helix of each piece must travel in the same direction.

In the careful consideration of item 2 we will obtain the solution and explanation of our paradox. Let the reader place on the table side by side, a right-hand nut, a right-hand tap and a left-hand tap, as shown in Fig. 4. Supposing now that we rotate these three pieces around this axis without changing their relative positions towards each other, keeping in mind condition 2. It then will be evident at once that the right-hand tap, although fulfilling conditions 1, 2, 3 and 4, does not conform to condition 5, for it will be seen that its helix travels in the opposite direction from the one of the nut, as indicated by the arrows. Turning our attention to the left-hand tap we find that in this case all five conditions are fulfilled. In gearing the tap and the nut by suitable means, conforming to the above conditions and allowing the tap to swing around the fulcrum D, we can cut the thread in the nut with the same ease as we have cut the thread on a bolt. Thus my second assertion: "To cut in a nut a right-hand thread with a left-hand tap," is made good.

At first sight, no doubt, the objection will be made that there is interference between the threads of the nut and tap from the reason that the tangent at the helices of the two parts in their point of contact do not coincide, but form an angle (the helices are of opposite hands). To this I will reply that to begin with the threads of the two parts (nut and tap) mesh perfectly along the section E F, Fig. 3. Beyond that point on either side one face of the threads clears very rapidly, owing to the difference in diameter of the two pieces. The other face clears not as well, I will admit, but the interference, as I have found in practice, is very slight in well-proportioned cases, and can very safely be neglected.

From a commercial point of view, the problem just explained is not a mere mechanical curiosity. The occasions where this method of cutting threads can be employed are many. I will not enlarge on them, but leave it to the reader to make applications. One case, however, I would like to mention, and this is in connection with gun making. As a rule, the barrel of a rifle is connected to the breech by being screwed into the latter, as into a nut. In Fig. 5 is shown a machine for cutting the thread on the end of a gun barrel. The headstock carries a long hollow spindle to receive the barrel, which centres itself properly, leaving exposed the part to receive the thread. A short carriage carrying the cutting tool or tap is moved by a hand lever. A second lever is used to bring the tool near the barrel. Stops regulate the motions of the carriage and tool, limiting the length and depth of thread. The driving pulley is placed on the headstock spindle, which is geared to a shaft running parallel to it

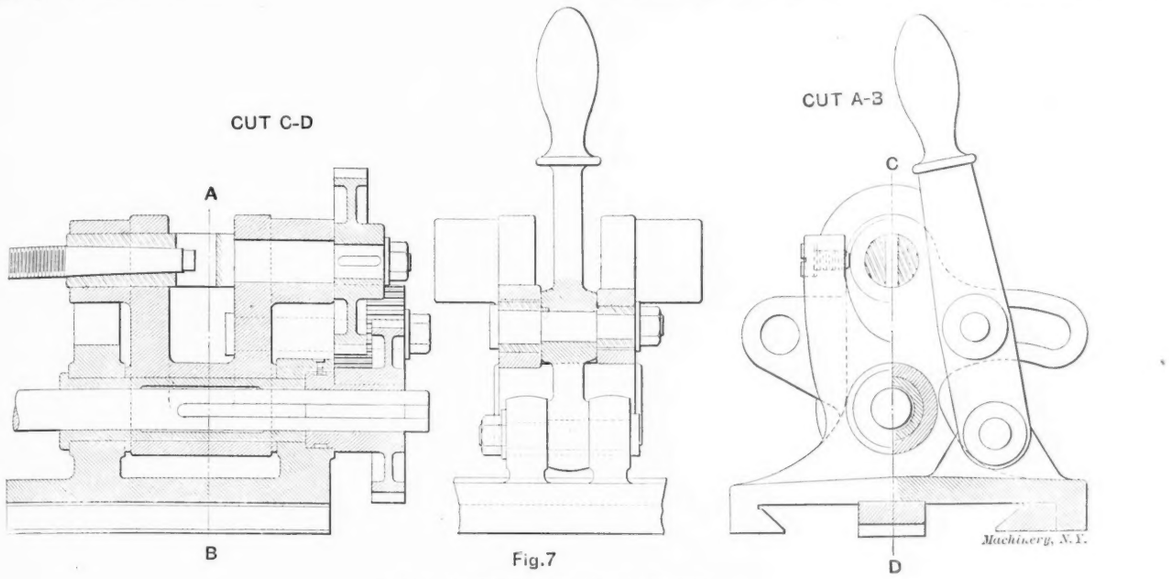


Fig. 7

Details of Carriage of Threading Machines.

and imparts motion to the tool, according to the requirements considered elsewhere. An oil-pump completes the equipment. Fig. 6 shows a similar machine. The main difference is found in the headstock spindle, which is constructed to receive the breech of the gun, a piece very irregular in shape. Fig. 7 shows the general arrangement of the carriage. The work done on these machines is far more expeditious than by any other method, while the quality is fully up to them. I would mention that, after the machines have done the work, a hand-tap or die is run over the threads to remove the slight burrs always thrown up when threads are milled. As far as I am aware, there are no patents covering the method explained. The first practical application was made about seven or eight years ago.

* * *

An eloquent though mute witness of former existing dangerous conditions which might easily have caused a disastrous fire, was noticed recently in the basement of a large hotel. A jointed gas burner fastened to the side of a closet had evidently been swung around by some careless person so the flame had scorched the wood until it was charred to a considerable degree. The danger of such an arrangement then being seen by the proprietor, the swinging burner was replaced by a stationary bracket. It does not require much of an imagination to picture what the result might have been in destruction of life and property under favorable conditions. While in theory it is supposed that the proprietors of all buildings take precautions to prevent fires, it is notorious that many of them do not, simply because they are careless or that it might entail extra expense. The insurance companies are entirely too lenient in taking risks and in keeping a proper surveillance of the buildings insured by them. The occasional canceling of a policy due to the vigilance of a watchful agent in every community would have a very noticeable effect in the reduction of the immense total annual fire loss.

* * *

The hardness of the diamond is proverbial, but nevertheless some of the experiments performed to demonstrate this are rather astounding. A perfect diamond has been placed between the ends of two opposing steel cones and subjected to hydraulic pressure sufficient to imbed it into the faces of the steel pieces, making a perfect matrix of its shape in each without injury to its structure.

MACHINE TOOLS, THEIR CONSTRUCTION AND MANIPULATION.—14.

TYPES OF MILLING MACHINES.

W. H. Van Dervoort.

The milling machine and its great popularity are due to the peculiar adaptability of the rotating cutter to the machining of plane and irregular surfaces on such a wide variety of work. The variety of work that the milling machine is capable of performing is much greater than can ordinarily be accomplished on the planer or shaper. In thoroughly familiarizing himself with these machines the mechanic has much more to learn as to settings and manipulation in the milling machine than in the planer and shaper. With the latter machines, however, more skill is required in the manipulation for the production of accurate work

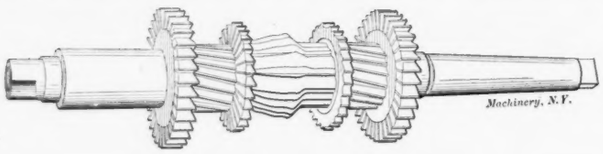


Fig. 126.

than with the former. This arises from the fact that on the planer all measurements must be separately made, inasmuch as the cutting tool generates the profile of the work by a series of parallel cuts, all changes in plane of the profile requiring separate adjustments and measurements. With the milling machine, however, the cutter is so formed as to generate the full profile of the work surface as the cutter advances, setting measurements alone being necessary. With the planing machines the accuracy of the work depends very largely upon the personal skill of the operator, while with the milling machine the accuracy of the cutting tool has much to do with the quality of the work. With

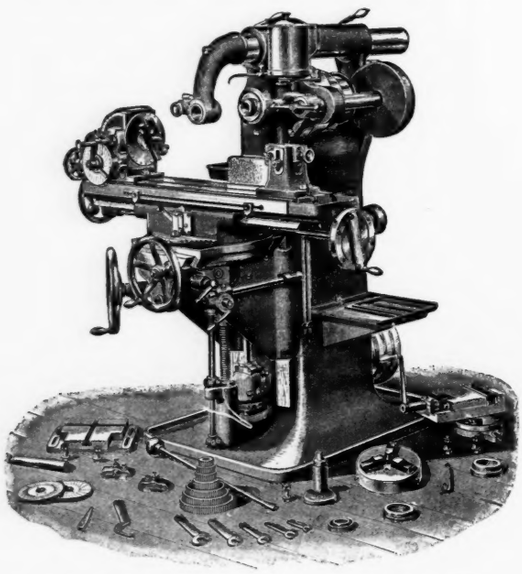


Fig. 127. Brown & Sharpe Universal Milling Machine.

the milling cutter and the work once set, the accuracy with which a certain work-surface profile can be produced upon one or more pieces depends wholly upon the wear on the cutting edges of the cutter. As the cutters are usually formed with a number of teeth, the work is divided up among these teeth, reducing the wear upon them. This is not only because each unit of length of each tooth performs only a small portion of the total work as compared with the cutting edge of the planer tool of unit's length, but because that particular portion of the tooth is performing work for only a small portion of each revolution, thus giving it an opportunity to cool and recover before each time it comes in contact with the work.

The advantage of the milling machine over the planer lies very largely in its ability to produce, with reasonable accuracy, a large number of duplicate surfaces, the formed cutter and removal of the personal error in the making of measurements by the operator being the factors that enable it to produce these results. For the producing of many plane surfaces and especially on work that is not to be duplicated, the milling machine possesses no advantage over the planer and shaper. Its advantages for certain classes of work, however, are great, as illustrated, for example, in Fig. 126. This shows a milling gang cutter made up of seven cutters and capable of producing at one traverse over the work a profile that, if produced in a planer, would require no less than eleven separate measurements, aside from the working out to line of the curved portion. It is only after the operator has become

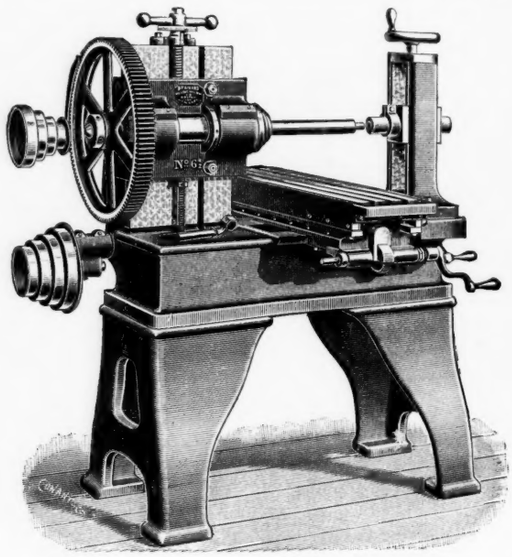


Fig. 128. Brainard Lincoln Pattern Milling Machine.

skilled in its use and thoroughly familiar with its every detail that he can appreciate the great capabilities of this class of machine tools, and fully understand how great the mistake of some shop owners in thinking that cheap, inexperienced labor is good enough to produce satisfactory work on the milling machine.

The plain and universal milling machines of the column pattern are most extensively used for general shop purposes. In Fig. 127 is shown a universal machine of this pattern. The column and knee resemble somewhat the same parts in the shaper.

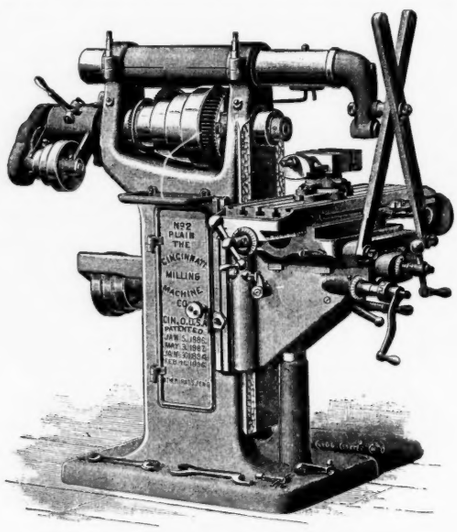


Fig. 129. Cincinnati Plain Milling Machine.

The upper portion of the column carries the spindle and cone, the spindle on all other than the smallest sizes being back-geared in precisely the same manner as on the lathe. The outer end of the spindle is always supported by a suitable overhanging arm. The work table is adjustable in and out from the face of the column and vertically, these adjustments being made by screws with operating handles conveniently placed and moving over

dials graduated to measure the amount of table movement in thousandths of an inch. The knee is gibbed to the face of the column and, in the universal machine, the work table is gibbed in a swing frame which pivots to a slider, which in turn is gibbed to the upper face of the knee. Through the office of the swing

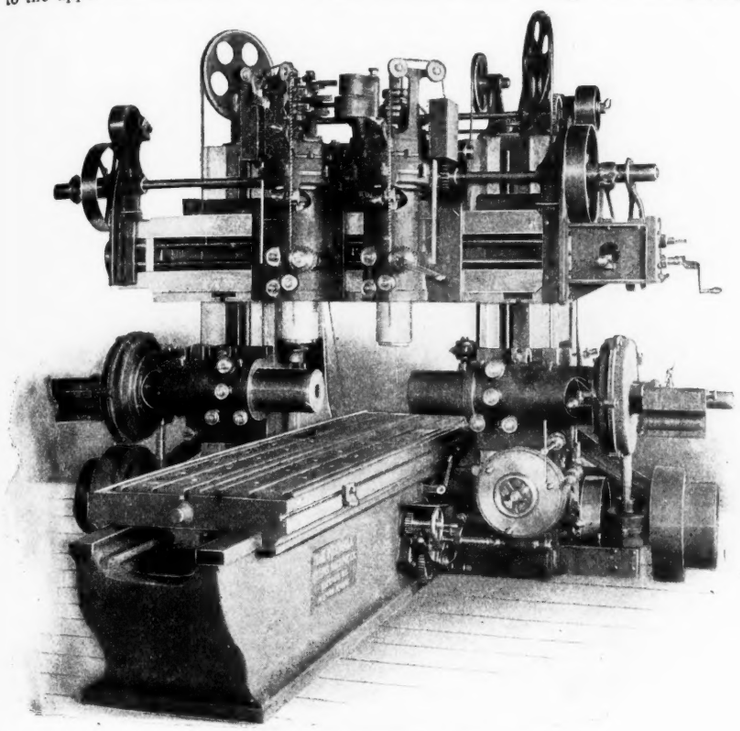


Fig. 130. Ingersoll Four-spindle Milling Machine.

frame the table can be set at an angle from its right-angle position with the cutter spindle. In some machines the table can be carried through a complete revolution, while with others the range is limited. The table is provided with a longitudinal feed automatically operated in either direction. An automatic in-and-out and up-and-down feed may also be applied when desired. The feed mechanisms are so designed as to give a wide range of feeds. The universal head to be described hereafter may be geared with the longitudinal feed screw for the cutting of spirals. The plain milling machines of the column pattern are similar in design to the one shown in Fig. 129. In this type of machine the work table is gibbed directly to the slider and its line of travel restrained entirely to one at right angles to the spindle. The universal head and tailstock of the universal type are omitted, plain dividing centers usually being used on these machines. The work table is somewhat larger on the plain than on like sizes of the universal machine. The plain machines are preferable for plain milling work, as they are somewhat more rigid and simpler in construction.

For tool room work the universal column pattern machine stands at the front. As probably more than 95% of the milling work outside of the tool room is plain milling, we find the plain machine much in favor for general work. Although the column pattern is generally conceded as the proper style of design for the universal machines, such is not always the case, for plain machines, inasmuch as a great part of the plain milling runs into larger and heavier work. We therefore find plain milling machines built along entirely different lines, especially when used for the plainest and heavier classes of work. In Fig. 128 is shown a form of plain machine commonly known as the Lincoln pattern. It is an exceedingly simple form of machine, yet very efficient on certain classes of work. The outboard support, for the spindle, together with the form of the bed, makes a rigid machine. The driving cone is mounted on the back side of the main upright, driving the spindle through a pinion and gear connection. As the vertical adjustment is in the spindle itself instead of in the work table, a suitable tightener is employed for keeping the belt tensions correct for all positions of the spindle. The work table is given the usual automatic feed under the spindle and suitable lateral hand adjustment. In Fig. 131 is shown a form of plain milling machine somewhat similar in appearance to the one shown in Fig. 128. The design, however, provides for a larger work table and the machine shown has two heads, making what is usually termed a duplex miller. Machines of this class are well suited not only to the use of plain or axial cutters, but to the radial or end cutter. Thus on the double-head machine of Fig. 131 two radial cutters may be used at the same time on opposite sides of work secured to the table; or one axial cutter can machine the upper surface while a radial is working on the side.

Fig. 130 illustrates what is known as a slabbing milling machine. It resembles in appearance a planer, is a massive, powerful machine, and in the form shown carries a large slabbing cutter for removing heavy cuts at coarse feeds from the work. These machines are also provided with a vertical spindle which can be operated with or independently of the horizontal spindle. In this case the vertical spindle head is carried on a saddle which moves over the cross rail and the horizontal spindle bearings are carried on the front faces of the housings. The vertical spindles usually carry radial mills. The advantage of the radial mill over the axial cutter lies in the fact that in forcing it to its cut the pressure is mostly in the direction of the line of the feed and not at right angles to the surface being machined, thus overcoming most of the springing in the work that occurs or tends to occur in the use of the axial cutter. The radial cutter, however, does not leave as smooth a surface as the axial, but this disadvantage is, on a great deal of work, more than overbalanced by the greater accuracy obtained.

In Fig. 133 is shown a well-known vertical milling machine intended for such general work as can be more advantageously performed by a cutter operated in a vertical spindle than by one on the horizontal spindle pattern machines. This machine in

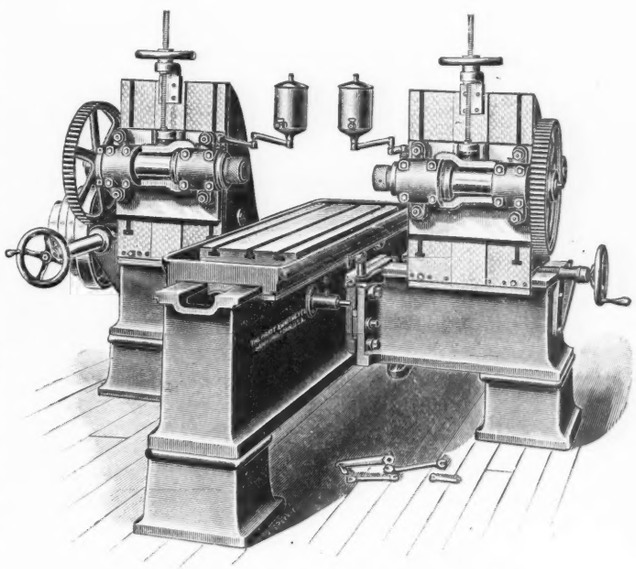


Fig. 131. Pratt & Whitney Duplex Milling Machine.

many respects resembles the regular column pattern machines with the column carried upward and out over the table, an amount sufficient to bring the spindle into the vertical position. The vertical spindle brings the cutter more directly under the sight and control of the operator than when cutters of the radial class are used in the horizontal spindle machines. This type of

machine also has the advantage of a circular feed by which a circular table upon which work is placed may be given a rotary motion. Thus a class of work may be performed that would otherwise require the use of formed tools in the lathe, and it can be done more quickly than in the lathe.

Another form of vertical spindle milling machine is shown in Fig. 132. This machine is designed for longer and heavier work than the one last mentioned. The spindle is carried on a radial arm, thus providing a cross adjustment to the spindle rather than the table.

The feed mechanism differs quite widely on machines by different builders up to the point of the connection with the work table. At this point one of two systems is invariably used—the screw or the rack feed. With only a few exceptions the screw feed is used on the plain and universal machines of the column pattern. On the heavy slabbing and duplex machines the rack feed is usually employed. The rack feed furnishes the best form for a quick movement of the table, but possesses the disadvantage of allowing the table and work to draw under the cutter in cases of accident or carelessness on the part of the operator. With the screw feed the table can be moved only by the rotating of the screw. A quick-geared return to the table is usually applied to the screw-feed machines.

The work table is provided with T-slots for holding the clamping bolts and fixtures. The tables are gibbed to the bed to prevent lifting and usually move in flat or angular guides. The overhanging arm is usually made of the style shown in Fig. 127, which enables it to be changed end for end to receive and support the several special attachments usually made to be used in connection with machines of the column pattern. Suitable ties are now furnished with most makes of milling machines connecting the outer end of the overhanging arm with the knees, which adds much to the rigidity of the table and spindle when heavy cuts are being taken.

Of the various attachments now supplied with the column type of milling machine may be mentioned that for vertical milling and attachments for cutting racks and gears, and for cam cutting.

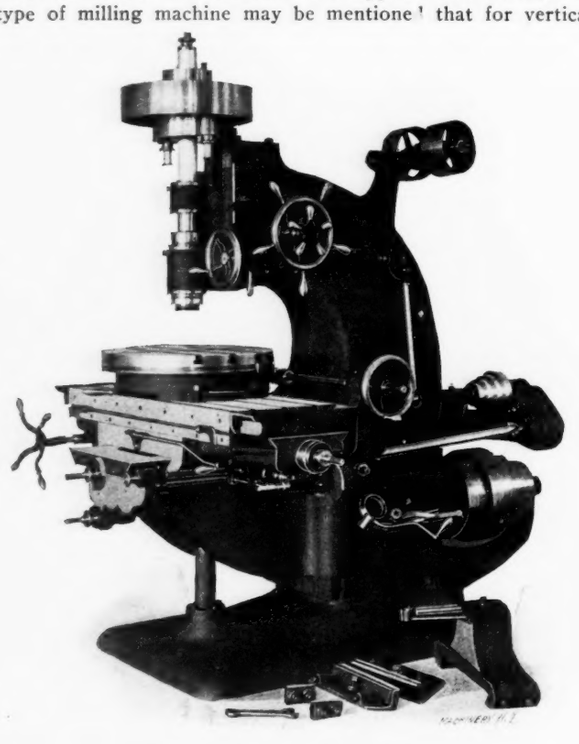


Fig. 133. Becker Vertical Milling Machine.

THE DESIGN OF TUBULAR BOILERS.—3.

MAN-HOLE COVERS, BRACKETS AND OTHER DETAILS.

CHAS. L. HUBBARD.

Lower Channel Bar.

Take a section of the channel, as shown by the heavy lines drawn ¼ the diameter of the heavy washers from their edges, and find the maximum "bending moment" by the equation:

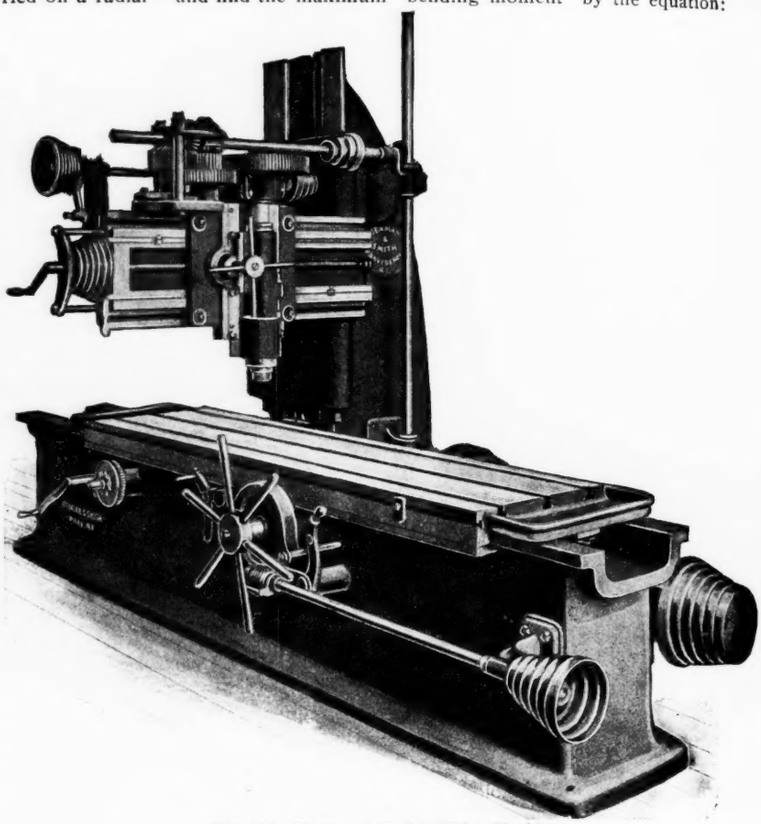


Fig. 132. Beaman & Smith Milling Machine.

$$M = \frac{W}{2} a \quad (16)$$

In which

M = the maximum bending moment,

$\frac{W}{2}$ = the load on a pair of rivets,

a = the distance of a pair of rivets from the nearest "heavy line."

Having found M, the required weight of beam or channel can be found from the relation,

Table XIV.

Diameter of Boiler.	Size of Feed Pipe.	Diameter of Boiler.	Size of Feed Pipe.
30"	1"	54"	1¼"
36"	1"	60"	1½"
42"	1"	66"	1½"
48"	1"	72"	1½"

Table XV.

Diameter of Boiler.	Size of Blow-off Pipe.	Diameter of Boiler.	Size of Blow-off Pipe.
30"	1¼"	54"	2"
36"	1¼"	60"	2"
42"	1½"	66"	2½"
48"	1½"	72"	2½"

Table XVI.

Diameter of Boiler.	Size of Steam Pipe.	Size of Safety Valve.
30"	3"	2"
36"	3½"	2½"
42"	3½"	2½"
48"	4"	3½"
54"	5"	4"
60"	5"	4"
66"	6"	5"
72"	6"	5"

$M = \frac{fI}{y}$, (17) in which

I = the moment of inertia of the channel.

y = the distance from the most strained fiber to the neutral axis.

f = the maximum stress in this fiber, which may be taken as 16,000 pounds for rolled steel channels and angles.

The value $\frac{I}{y}$ is called the "moment of resistance" or "section modulus." Manufacturers of steel beams publish handbooks giving this and other properties of channels, and angles of different sizes; so, having the value of $\frac{I}{y}$ for any special case, the required size of beam can be found at once from such a book. Channel bars used in this way have the neutral axis parallel to the web, and care must be taken in looking up the "moment of resistance" in a hand-book to select the value given for this condition.

Upper Bar.

This is made up of a channel and an angle riveted together, as in the section Fig. 5, November issue, the whole being treated as a single beam.

In this case there are 3 pairs of rivets between the stays. Heavy lines are drawn through the washers as before, and the maximum bending moment found by the equation $M = P A - pa$ (18), in which

P = 1-2 the load carried by the 3 rows of rivets included between the heavy lines,

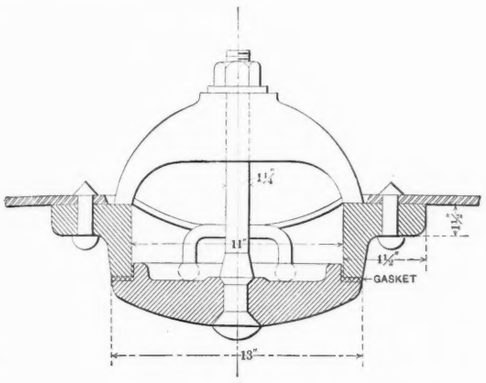
A = the distance from the middle rivets to one of the heavy lines.

p = the load on one of the end rows of rivets,

a = the distance between the end and middle rows of rivets (By end rows of rivets are meant those next to the heavy lines and included between them).

Having solved for M, the "moment of resistance" can be found as before, and the channel and angle be given such sizes as will make their combined strength sufficient to meet the necessary requirements. It is customary to make the upper and lower channels of the same size, so in proportioning the angle and channel of the upper bar, care must be taken not to make the channel smaller than is required for the lower bar. For high pressures it is often found that standard channels do not give sufficient strength. In this case it is necessary to use two angles instead, this form of bar being made in a greater variety of sizes and weights.

Where angles are used, it is necessary to counterbore slightly to give a flat bearing for the checknut upon the stays on the inside of the head. This is shown on the lower bar of the section in Fig. 5. In laying out this form of bracing it is customary to assume the channels of a suitable width to give the proper spacing for the rivets, and then compute the required weight by the methods given.



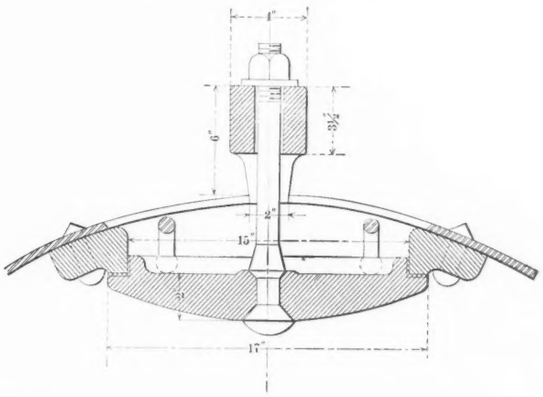
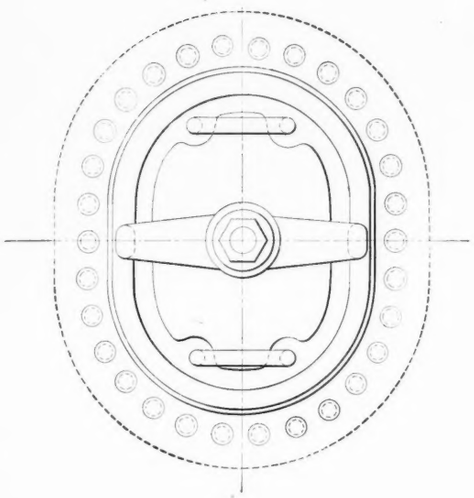


Fig. 16



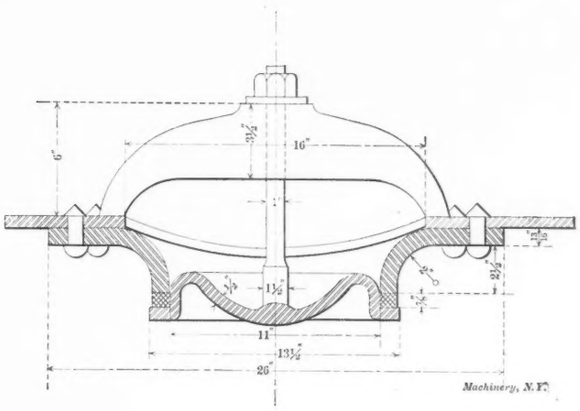


Fig. 17.

Man-hole.

Access to the boiler is provided for by a manhole placed in the top of the shell. Fig. 16 shows a common form having a heavy internal frame and plate, made either of gun iron or cast steel. The plate is held against its seat by a bolt and yoke and is made tight by means of a gasket. The manhole is sometimes located in the front head of the boiler, a number of tubes being omitted for this purpose. Where this is done, additional braces must be provided to offset the removal of the tubes.

Table XVII.

Size of Safety Valve	1″	1½″	2″	2½″	3″	3½″	4″	5″	6″
H. P. of Boiler	25	37	47	58	67	76	84	98	110

Table XVIII.

Size of Safety Valve.	H. P. of Boiler.	Size of Safety Valve.	H. P. of Boiler.
1″	5 to 10	3″	75 to 100
1¼″	10 " 20	3½″	100 " 125
1½″	20 " 30	4″	125 " 150
2″	30 " 40	5″	175 " 200
2½″	40 " 75		

A form of wrought-iron or steel manhole, shown in Fig. 17, is often used for high pressure work.

Handholes.

Handholes are placed in each head below the tubes, to provide means for washing out the boiler. Fig. 18 shows a common form. They are provided with bolt and yoke like the manhole but have no frame, the gasket being placed directly against the boiler shell. A clear space of at least 1 inch should be left between the tubes and the edge of the handhole to provide a proper seat for the cover.

Feed Pipe.

The boiler feed should be delivered in such a manner that contact between the cool water and the hot plates shall be the least possible. Various devices have been used for this purpose. The more usual method is to enter the feed pipe in the front head just above the tubes, extending it to within about 2 feet of the rear head; then across and down between the tubes and shell, where

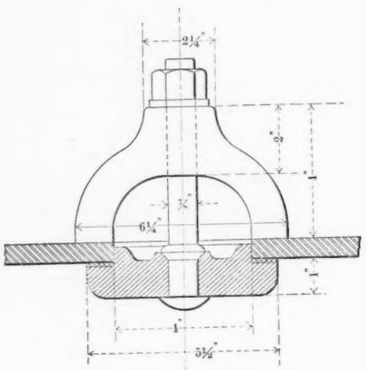


Fig. 18.

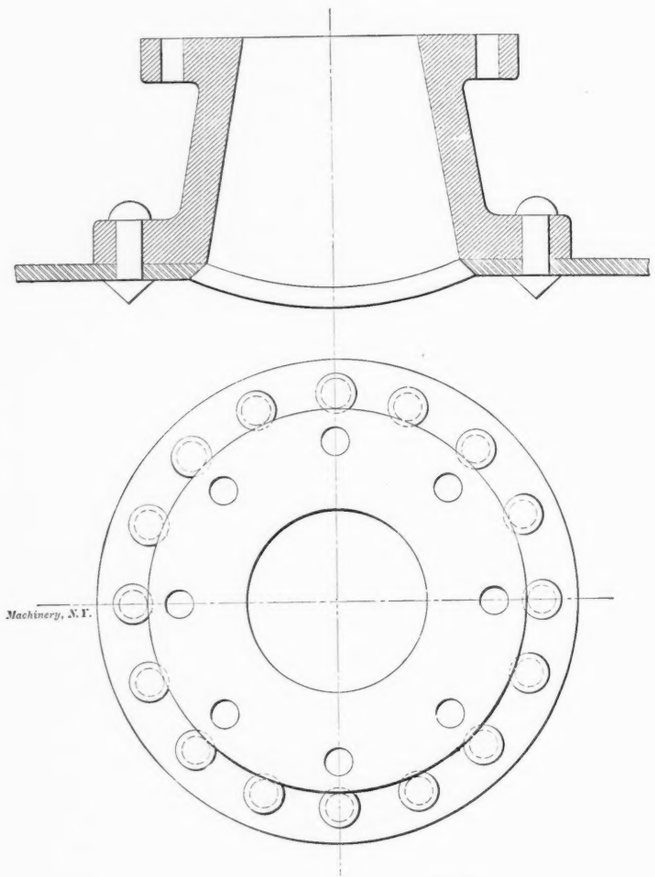


Fig. 19.

the end may be plugged and the water discharged through a number of small holes drilled in the pipe. The portion passing through the front connection should be of heavy iron and the remainder of brass. Table XIV, page 110, gives usual sizes of feed pipe for boilers of different diameters. These are proportioned for the maximum lengths of the different diameters of shell, as commonly used, and are therefore safe for all usual cases.

Blow-off Pipe.

A blow-off pipe should connect with the shell at the bottom near the rear head for draining the boiler. The shell at this point is reinforced by means of a metal plate ½ or ⅝ of an inch thick, riveted in place. Where the pipe is exposed to the hot gases in the back connection space, it should be protected by a cast iron sleeve packed with asbestos or mineral wool. Other means of protection are often used; a V-shaped deflector of fire brick open at the rear, for inspection, is said to give good results. Table XV gives sizes of blow-off to be used for boilers of different diameters. Where this pipe acts as a gravity return for a heating system, it may be a size larger than given in the table.

Nozzles.

Table XVI gives the sizes of steam pipes and safety valves that work satisfactorily in connection with heating plants, and can be safely adopted for this class of work. These are proportioned for the maximum length of boilers, as already stated, in case of the feed pipe, and are therefore somewhat larger than is necessary for the shorter lengths; but the defect is on the safe side and the table sufficiently accurate for ordinary use.

For power boilers the requirements may be somewhat different, depending upon the size of the engine supply pipe, length of run, etc. The nozzles are usually made of cast steel or gun iron and are securely riveted to the shell. They are commonly of a uniform diameter, but it is better to flare them somewhat, making the bottom where it joins the boiler shell larger than the outlet, as in Fig. 19. This facilitates the flow of steam and is recommended for high pressures.

It is preferable to take the steam from the rear nozzle, as the boiling of the water is less violent at that point and spray is not so likely to be carried over with the steam.

Safety Valves.

There are a number of rules for determining the size of a safety valve, each giving a different result. Kent gives a comparison of the results obtained by different methods of calculation for a 100 H.P. boiler in which the required areas vary from 5.25 to 57.6 square inches.

For lever valves he gives the sizes in Table XVII as probably corresponding well with ordinary conditions.

Where a diameter of over 4 inches is called for, it is customary to use two smaller ones having an equivalent capacity.

Table XVIII taken from the catalogue of the Crosby Steam Gauge and Valve Co. seems to give average capacities as compared with figures given by other makers, and with results obtained from approved methods of calculation.

Brackets.

Horizontal tubular boilers may be supported in two ways, the more common being by means of cast-iron brackets resting upon

the brickwork of the setting. The brackets are so placed that their bearing surfaces are 3 or 4 inches above the center of the boiler.

Boilers up to 17 feet in length are furnished with 4 brackets, while those of greater length have a third pair placed midway between the others. The front pair are firmly embedded in the masonry of the setting, while the others rest upon iron rolls to provide for the movement due to the expansion of the boiler. The rolls as well as the front brackets rest upon heavy wrought or cast-iron bearing plates of a width to correspond with the

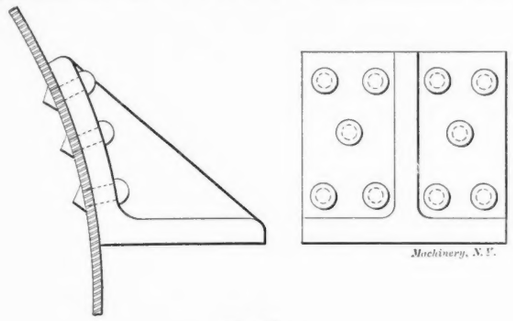


Fig. 20.

projection of the brackets from the shell, and having a length from 16 to 20 inches, according to the size of the boiler. Figs. 20 and 21 show usual forms of brackets used for this purpose.

Fig. 20 is the more common, while the other has the advantage of being riveted to the shell below the projection, which gives it added strength. Table XIX will be found useful in proportioning brackets for different sizes of boilers.

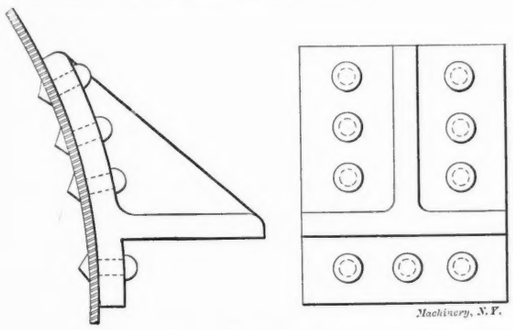


Fig. 21.

Boiler makers, however, have standard patterns for brackets which they use; so in specifying work, it is usually as well to rely on forms and sizes which their experience has found satisfactory rather than go to the expense of special patterns. This applies equally well to manholes, nozzles, etc. The examples given here will be found useful for comparison as representing the best practice in common use, and also for purposes of design when it is desired to use these particular forms.

Table XIX.

Diameter of Boiler.	Length of Bracket.	Projection from Shell.	Thickness of Bracket.	Size of Rivet.
30″	9″	8″	1″	¾″
36″	9″	8″	1″	¾″
42″	10″	9″	1¼″	⅞″
48″	10″	9″	1¼″	⅞″
54″	10″	10″	1½″	1″
60″	10″	10″	1½″	1″
66″	12″	12″	1⅞″	1 1/16″
72″	12″	12″	1⅞″	1 1/16″

Boilers are sometimes supported by lugs or straps riveted to the shell and are hung from overhead girders. When this means of support is used, a boiler may be removed from a battery for repairs or renewal without seriously disturbing the other boilers.

Fusible Plug.

Danger from overheating the plates of a boiler is guarded against by means of a fusible or safety plug, which consists of a brass bushing with a core of some fusible metal which melts before an excessive temperature is reached. The steam and water blowing into the furnace will check the fire to some extent, and also give warning to those in charge. In a cylindrical tubular boiler the fusible plug is screwed into the rear head at a point about 3 inches above the upper row of tubes. To be efficient, the plug should be of good length and the core made tapering in form, with its larger end toward the steam pressure to prevent blowing out.

Water Glass and Gage Cocks.

The water line in the boiler is indicated by a water glass and gage cocks. These may be connected directly with the front head or with a cast-iron chamber called a "combination box" which in turn is connected with the boiler at top and bottom by a 1¼-inch pipe. The upper connection enters the steam space on top of the boiler shell and the lower passes through the head at a point near the bottom row of tubes. It is customary to place the bottom of the glass about 2 inches above the top of the upper row of tubes. The gage cocks are for the same purpose as the water glass, and can be used in case anything interferes with the proper working of the former.

Steam Gage.

Each boiler in a battery should be provided with its own gage for indicating the pressure. This may be connected directly with the steam space by an independent pipe or may enter the top connection of the combination box. The pipe should be supplied with a siphon or loop which will become filled with water and prevent steam from entering the gage.

Smoke Pipe and Dampers.

The smoke connection between the boiler and chimney stack is usually made of No. 10 or 12 black iron. It may be either round or rectangular in section, although the former is preferable, especially for small sizes, and is more efficient for a given area. The larger sizes of rectangular pipe should be stiffened by riveting angle iron in the corners. Doors of suitable size should be placed in the pipe at intervals to give access for the purpose of cleaning.

Where two or more boilers are connected with the same smoke pipe, there should be a damper for hand regulation in each uptake, in addition to the balanced damper in the main pipe. The small dampers should be furnished with means for holding in any position desired. The main damper should be provided with roller bearing and connected with some form of reliable regulator of which there are several makes.

* * *

1905.

Place—Mr. Tom Read's plumbing shop, Fulton Avenue, Brooklyn.

Time—June, July or August, 1905.

"Hello!"

Ting-a-ling--a-ling-a-ling-a-ling-aling-r-r-r.

"Is this Mr. Read's plumbing shop?"

"Yes.

"Well, this is Mrs. Schuyler Suydam of Washington Avenue. Please, Mr. Read, send a couple of men at once. We are in an awful state with the liquid air around here. Please have your men bring their big torches with them and don't delay. We are in a terrible condition. I fear for the lives of Fido, my pug, and Bridget, the cook."

"I will send a couple of men at once, Mrs. Suydam. Goodbye."

Next morning—Mr. Read to his liquid air plumbers—"What was the matter, boys, around in Mrs. Suydam's?"

"Well, the cook was fillin' a two-ounce bottle of Arctic out of the supply needle valve and she accidentally dropped it and it broke. In a second or two she was covered with a coating of frost about a foot thick. One or two drops got on the pug dog and put him out of business. We had no time to thaw out the dog, so we trun him out in the sun gently as we thought, but he was too much friz and he bruk in about a thousand bits. We thawed out th' cook, though, and she's in th' hospital. Th' doctor says she'll be all right in a week or so. You didn't put in the plant, so we told Mrs. Suydam that the generators wanted overhaulin', which they do, and the lead connections to the compressors are too light; they are ¾ and only weigh 18 pounds to th' fut, when they should weigh 24. She said by all means to put them in shape."

Mr. Read—"Very good. There's another job on Greene Avenue you're wanted on. The liquid air valve that cools the rear of the house began to leak last night and there are three feet of snow in the front and back parlors, and the temperature is 30 degrees below zero. So do what you can in a hurry boys, to help them out."—Plumbers' Trade Journal.

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DECEMBER, 1900.

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1900.		1900.		1900.	
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February ...	20,500	June	27,500	October	24,000
March	25,000	July	22,000	November ..	25,000
April	21,500	August	21,500	December ..	27,500

The usual data sheet for this quarterly number is omitted and instead extra reading pages have been added.

* * *

December is the last month of the nineteenth century, and on the following pages will be found a review of the century's work in the field of mechanics. In looking through the summary that we have prepared, one cannot fail to note the direction in which events have been drifting, and it is reasonable to expect that they will continue in about the same way, under the tremendous impetus of the past century of invention. In the first few years of the century the people were largely concerned with agriculture and their products were home-made. Their needs in the line of manufactured articles were for the ordinary necessities of life, and we find much attention given to the production of textile goods, nail making, and later to the manufacture of pins and such small products as were wanted for every-day use. The great problem of power for transportation and factories was then unsolved. There was not even machinery for reducing the labor of agricuture.

With the improvement of the steam engine came the invention and manufacture of the necessities of life and the facility for the transportation of raw materials and finished products. With electricity came the opportunity for conducting enterprises on a larger scale than dreamed of a hundred years ago. It would seem scarcely possible that in another hundred years there could be so many remarkable inventions pertaining to ordinary needs and the ordinary forces of nature. People are freed from anxiety as to the invention of useful and needful articles, and it would seem that we are now to enter an era in which all forms of engineering construction will be attempted of a magnitude unprecedented. The work that has been done has furnished the tools, so to speak, for conducting enterprises on a vast scale, of which the work of the past ten years affords an indication.

* * *

EARLY USE OF THE MILLING MACHINE.

The milling machine, of which several forms are illustrated in this issue, is commonly regarded as a modern machine tool, as it has been during the past two or three decades that it has come prominently into use as a general and indispensable tool for the machine shop. However, the use of the revolving cutter and therefore some form of the milling machine, since the revolving cutter is its distinguishing feature, is ancient. There is evidence to show that the teeth of wheels were cut with revolving cutters as early as 1664, by a Dr. Hooke. This interesting bit of machine history, while vague and unsatisfactory as to details, is evidently quite trustworthy. Whether the Dr. Hooke referred to was a doctor of men or a doctor of clocks, we know not, but it is quite evident that the milling machine in various crude forms was quite commonly known and used by the early watch and clock makers. It is also evident that nothing could be more obvious for saving labor in the making of the toothed gearing of time pieces, whether of wood or metal, than a simple indexing device for spacing and a revolving cutter for "notching."

The early clockmakers of New England are credited as being the first users of the milling machine in the United States and the claim seems to be well founded. The toothed wooden wheels of the old "grandfather's clocks" that many a boy now of mature age has had the pleasure of dissecting in his father's woodshed, bore in many instances, unmistakable evidences of some mechanical arrangement for regular spacing and getting uniform width and depth of tooth space.

Upon the advent of the lathe having the rotating spindle, about 1800, the milling machine could be easily adapted by the mere use of a revolving cutter fastened to the spindle. The first milling machine known to have been used in the United States for machine shop operations, was at Middletown, Conn., in 1818. It was a lathe headstock set on a suitable frame (which would now be highly unsuitable) and provided with a table having a transverse movement.

James Nasmyth, England, made a similar adaptation in 1829, in the shop of Henry Maudslay, the inventor of the slide rest for lathes, for smoothing the sides of hexagon nuts. In this machine the table having a transverse movement carried a vertical index head, having six holes for the six sides of the nut. The cutter appears to have been little more than a circular piece of hardened steel roughed with a chisel before hardening. In fact the revolving cutter was known as a circular file.

The idea of using a lathe for the early milling machines was quite common and seems to have practically been done by one of the early builders of milling machines, a now well-known firm, who in their first machines simply mounted a headstock on the base of a shaper and used the table of the shaper for the platen of the milling machine. Machines made by this firm are in use to-day, showing unmistakable evidences of this very simple and practical combination.

The primary use of the revolving cutter appears to have been in cutting the teeth of gears, and along these lines the development of the milling machine has generally been until within a comparatively few years. This is, of course, not universally the rule, as the machine referred to in 1818 was a "slabber," but the use of the revolving cutter in this way appears to have been isolated. Gear cutters were built in 1839 by Silver & Gay, North Chelmsford, Mass., and a full automatic machine for gear cutting by Gage, Warner & Whitney, in 1860, both machines using a revolving cutter.

CHRONOLOGY OF THE NINETEENTH CENTURY.

A RECORD OF MECHANICAL PROGRESS DURING THE PAST ONE HUNDRED YEARS—IMPORTANT EVENTS IN THE DEVELOPMENT AND APPLICATION OF MACHINERY, CHIEFLY IN THE UNITED STATES, AND TO SOME EXTENT IN OTHER COUNTRIES.

The chronology on this and the following pages is published to place on record, in convenient form for reference, some of the important mechanical events in the development and application of machinery during the nineteenth century. No attempt has been made to include all classes of machinery nor all the important inventions or events connected with any one class. A sufficient number of dates and items has been compiled, simply to show the trend of invention and the advance from year to year during the 100 years which close with this month.

The scheme of preparation has been to select representative subjects, like locomotives, turbine water wheels, machine tools, iron making, electricity, etc., and to give enough items to indicate the progress of their development. While most of the matter relates directly to machinery, there are other subjects so intimately connected with it and its growth, that they have been included, while on the other hand many inventions in other departments of work have been omitted.

In preparing this list, recourse has been had to available historical works or articles in periodicals and the transactions of societies, that bear the stamp of original research and are believed to be authentic. The dates of patents have been of material assistance and in addition to these sources we wish to acknowledge our indebtedness to many individuals and firms who have kindly assisted us.

CHRONOLOGY OF THE CENTURY.

1801.

Carding machine run at Chelmsford (Lowell, Mass.) by Moses Hale.

Tarascon, Berthoud & Co., from Philadelphia, built vessels to navigate the Ohio.

Oliver Evans, Philadelphia, completed a high-pressure steam engine, cylinder 5 x 18 inches, at a cost of $3,700, which he applied to grind plaster of Paris. Later it was used for sawing marble. This engine was on the same plan as one patented in the same year by Trevithick, England, to whom Evans had sent drawings.

Sheet copper made at Canton, Mass.

Jacquard patented in France a loom by which cloth could be woven from a pattern consisting of perforated cards, the perforations serving to raise any of the threads of the warp for the passage of the shuttle.

Complete muskets were made interchangeable in the French armories under direction of M. Blanc. Parts were made interchangeable by drilling the holes through jigs.

Springfield armory established at its present site, but first started in 1795.

1802.

Manufacture of clocks by water power commenced at Plymouth, Conn., by Eli Terry. Had made clocks several years before.

Improvement in saw mill by which log is returned automatically after each cut.

Sir Humphry Davy discovered the principles of the modern arc lamp.

Richard Trevithick patented a steam carriage in England and in 1803 built one which was the first to run on a railroad track.

Joseph Bramah patented a planing machine for wood and metals, using a revolving cutter.

1803.

N. Y. legislature passed an act extending the term for 20 years to Messrs. Livingston & Fulton by which they had the rights and privileges of steam navigation on the waters of the state. Also extended the time in which they must demonstrate the practicability of the scheme. They made a successful trial on the Seine in this year and, encouraged by this, ordered an engine from Boulton and Watt, England, to be sent to America for steamboat use. Shipped in 1806 and used on the Clermont.

Vessel was built for one of Oliver Evans' engines, but through misfortune and lack of funds the engine was finally used for a saw mill.

Machine for cutting grain and grass invented by Richard French and John T. Hawkins, New Jersey.

The principles of the storage battery discovered by Ritter.

Machine for making a continuous web of paper invented by Louis Robert, a paper maker, at Essone, France, in 1799. Leger Didot, manager of the Essone mill, and John Gamble, an Englishman, took the invention to England. Byran Donkin had charge of the shops where the first machine was completed in 1803. Henry and Sealy Fourdrinier financed the experiments and the machine was named after them.

1804.

Twin screw propellers for marine vessels made by John Stevens, who supplied them to a vessel navigating the Hudson.

Oliver Evans completed a machine for cleaning docks by steam power. It consisted of a flat scow with an engine of 5 horse-power for operating the machinery. Having been fitted with temporary wheels, it was driven through the street to the river, and with stern paddle wheels was propelled 16 miles.

Iron foundry founded in Pittsburg by Joseph McClurg.

Manufacture of printing presses and materials commenced by Adam Ramage, Philadelphia.

Arthur Woolf combined the two-cylinder engine of Hornblower with higher steam pressure and Watts' condenser.

First "porcupine" water-tube boiler designed by John Cox Stevens. The water-tube boiler had been invented previous to 1800.

1805.

John Pennock, Boston, first recorded U. S. patent for a wood planing machine.

1806.

First load of anthracite coal taken from Mauch Chunk to Philadelphia. Coal found unmanageable and experiment not repeated for several years.

A water wheel first patented by Ephraim Hubble, Middlebury, Vt.

Samuel Slater, father of the cotton industry in this country, and his brother John, started the first of the Slater cotton mills in Rhode Island.

Davy performed experiments which greatly increased the knowledge of the chemical action of electric currents.

The first "cylinder" paper machine built by John Dickinson in England.

1807.

The "Clermont," the first steamboat built by Livingston and Fulton launched from shipyard of Chas. Brown on East River, having been supplied with an engine by Boulton and Watt. Soon after made a trip to Albany in 32 hours and later made regular trips and carried passengers. This event permanently introduced the era of steam navigation.

Printers' rollers introduced in Philadelphia by Hugh Maxwell.

Jesse Reed, Boston, made the most important inventions relating to nail machinery, in this and other years. During the first ten years of the century, improvements in nail making engaged a great deal of attention.

Davy discovered that the fixed alkalies could be decomposed by the electric current.

Henry Maudslay invented the direct-acting steam engine called the pyramidal engine on account of its form. Was the forerunner of the modern marine engine.

1808.

Steamboat Phoenix built by John Stevens navigated from Hoboken to Philadelphia, being the first instance of a steam vessel on the ocean.

Owen and Oliver Evans were interested in flouring mills.

Band saw made and patented by William Newberry, London.

1809.

The subject of a railroad agitated by Oliver Evans, who proposed to form a company and invest his whole fortune in the enterprise. Col. John Stevens also proposed it instead of a canal.

Power loom projected by Dr. Josiah Richards when a student in New Hampshire, but failed through some defect in the machinery.

Sommering, of Munich, invented a telegraph in which signals were given by means of chemical action produced by the electric current.

1810.

Isaac Pennock built an iron mill near Coatesville, Pa., where the first boiler plates are said to have been rolled.

Compressed air used for transporting goods by Medhurst and in 1818 by Vallance.

1811.

The steamboat New Orleans, the first that ran on western waters, was constructed at Pittsburg. Cost $40.000, one-half of which was re-imbursed by the first year's business. It was 138 feet long, built by Livingston and Fulton, and N. I. Roosevelt.

There were, this year, five steamboats running from New York to Albany, one to New Brunswick, one in Lake Champlain, one

on the Ohio, and one on the St. Lawrence. There were also building a Hudson River ferry boat, in which Fulton embodied many of the ideas still used in these boats.

The first machine invented for pegging boots.

Frederich Koenig produced a cylinder press in Germany, with a reciprocating bed driven by a pinion traveling first on the upper and then on the lower side of a rack attached to the bed. This press had several of the elements found in modern presses.

1812.

One of the largest woolen mills in the country was at Middletown, Conn.; made from 30 to 40 yards of broadcloth per day, which sold at $9 to $10 per yard. The mill was driven by one of Evans' engines.

Evans had 10 engines in use, of from 10 to 25 H.P. each. One in Florida, one in Louisiana, one in Kentucky, one in Mississippi, one in Ohio, two at Pittsburg, one at Middletown, and one in the works of the builder at Philadelphia. He set up an engine this year at Providence.

Bar iron $110 a ton.

The preparation of emery and corundum begun.

Manufacture of pins commenced by English pinmakers at Greenwich, N. Y. Their price had been $1 per paper.

Attempts to manufacture the power loom were made, in view of its recent success in England. F. C. Lowell and P. T. Jackson produced a successful working model. Machine built by their orders, first successful American power loom. This loom virtually prevented the ruin of the cotton industries a few years later, through English competition.

First cotton mill at Fall River, Mass., then called Troy.

Nine loads of anthracite coal hauled to Philadelphia. Two sold for cost of transportation, and the rest were given away, the owners being accused of trying to sell stone for coal.

First use of anthracite in manufacture of iron at the Falls of the Schuylkill. Not very successful because a hot blast was not used.

1813.

The first stereotyping in America was done at the Bruce foundry, New York.

Extensive iron works established at Au Sable, N. Y., which are still in existence.

Cotton manufactured at Chelmsford, Mass. (now Lowell, Mass.).

The most interesting event of this year was the establishment at Waltham, Mass., of the first complete cotton manufactory in this country, with about 1,700 spindles, in which the power loom was used. Cotton mills in the United States had been principally for spinning, the weaving being done elsewhere on hand looms. Enterprise due largely to Francis C. Lowell, who was instrumental in introducing the power loom, and after whom the city of Lowell was named.

Davy produced a brilliant arc light with current obtained from a battery of 2,000 cells.

Demonstrated in England by experiments with a weighted car operated by man power that the weight of a locomotive and its friction on the rails would be sufficient to render steam motive power possible. Hedley, who performed the experiments, constructed the "Puffing Billy" based upon the knowledge gained, which was successful.

John Harrison, Philadelphia, introduced from France a method of converting crude grains of platinum into bars and sheets on a commercial scale.

1814.

First steam war vessel launched. Was the invention of Fulton and was named Fulton the First. One hundred and fifty-six feet long, the bulwarks of the main deck were of solid timber, 14 feet high and 10 inches thick. Thirty-two guns were carried and the engine had a cylinder 48x60 inches. Fulton died before completion of the boat but, when finished, it was a success and steamed 5½ miles an hour.

First steam ferry began running between New York and Long Island, designed by Fulton.

Cannon foundry, the beginning of the Fort Pitt Iron Works, established at Pittsburg. For several years the cannon were bored by horse power.

The second engine in Providence erected, of 24 H.P. Cost $17,000, a large part of which was for transportation.

Moses L. Morse invented a machine for manufacturing pins from wire at one operation.

A gun for firing hollow projectiles at long range, called the "Columbiad," invented by Col. Bomford, U. S. A.

James Fox, England, said to have built his first planer. Matthew Murray also had one in operation in this year.

Brunton's coking stoker for boilers brought out, but it was not the first, as Watt had patented a mechanical stoker in 1785.

1815.

The original steam power water works at Fairmount, Philadelphia, were put in operation, a Boulton & Watt engine having been erected. In 1817 one of Oliver Evans' engines was started at this plant.

1816.

At this time the manufacture of rope, leather goods, iron castings, fire arms, window glass, paper and type was sufficient to meet the demand. The manufacture of textile goods, iron products of large size, agricultural implements, and nails partially met the demand. The finer textile goods, hardware, and the smaller iron products, earthenware and glass other than window glass were mostly imported.

The first steam paper mill of the country started at Pittsburg.

New power loom invented by E. Savage, Boston, for unusually wide goods.

Baltimore and several other places lighted by gas.

Ronalds invented a telegraph in which signals were given by the swinging of electrified pith balls.

The first continuous web "cylinder" paper machine in America, built near Wilmington, Del., by Thomas and Joshua Gilpin and John Greatrake.

James Watt invented a lathe for turning irregular forms similar to the Blanchard lathe.

Richard Roberts, Manchester, brought out an improved screw lathe.

Dowson's underfeed stoker patented.

Richard Roberts, Manchester, Eng., cut gear wheels with some form of a milling machine.

1817.

First puddling and rolling mill for production of bar iron at Plumsock, Pa.

Phineas Doll and Daniel Treadwell, Boston, invented a machine which finished wood screws from a coil of wire at the rate of ten a minute.

Thomas Blanchard invented a brad and tack machine.

George Clymer completed the Columbian hand printing press which used a form of the toggle joint in place of the screw for securing the impression of the platen. Previously the platen had been operated by a screw.

1818.

First Lake Erie steamboat launched near Buffalo.

Probably the first milling machine made and used in the United States at Middletown, Conn., for the manufacture of fire arms.

Jesse Reed, Kingston, Mass., brought out a machine for making nails that did away with slitting the metal before cutting off the nails.

One of the first important improvements in iron making was the substitution of the iron bottom for the sand bottom in the puddling furnace by Samuel B. Rogers.

1819.

Thomas Blanchard invented the so-called "Blanchard lathe" for turning gun stocks.

Steamer Savannah, of 380 tons, steamed and sailed from Savannah to Liverpool, being the first steamer to cross the Atlantic. She was formerly a sailing vessel built in New York.

Cooking stove invented by John Conant, Vt.

Oersted discovered that an electric current will deflect a magnetic needle. This was the beginning of the science of electromagnetism.

Jethro Wood produced a cast-iron plow similar in form to the modern one.

1820.

A steamship, the Robert Fulton, 1,000 tons, built this year, by Henry Eckford, New York. She attained the speed of 9 miles an hour which was regarded as a maximum speed for steamboats and was not surpassed for many years.

Two anchors of 8 and 9 thousand pounds weight, respectively, forged by Hunt Bros., South Canaan, Conn.

Ampere followed the work of Oersted and developed the laws of electro-dynamics.

The roller mill for grain invented by Helfenberger, Switzerland.

Steam heated dryers, for drying paper, in the process of manufacture, were first used.

1821.

Samuel Rust, New York, patented the Washington hand press, in which the platen is forced down upon the type by a toggle joint and raised from the type by springs and the bed is run out or in by a crank and strap connection.

First sectional water-tube boiler made by Julius Griffith.

Michael Faraday caused a wire carrying an electric current to rotate around a magnet, and a magnet to rotate around the wire. This was the beginning of electric motors and generators.

1822.

First engraving of cylinders for calico printing in the United States.

Steam power introduced in sugar manufacture.

Iron conduit pipes successfully used at the Fairmount Water Works, Philadelphia. Cast in sections of 9 feet long and 2 to 22 inches diameter.

B. & J. Tyler and B. J. Andrews, Windsor, Vt., made a threshing machine, run by horse power.

Stanley's sprinkling stoker patented.

Robert L. Stevens, son of John Stevens, is the originator of the American beam engine used on paddle-wheel boats. In this year he used the skeleton beam on steamship Hoboken, and in 1827 the "hog frame" for beam engines.

1823.

Act passed through the efforts of John Stevens to incorporate the Pennsylvania Railroad Company to build a railroad from Philadelphia to Columbia, Lancaster Co.

First application in this country of tin as a lining or coating to metallic tubes or plates, by Thomas Ewbank, New York.

The differential motion for Roving frames patented by Asa Arnold. This is one of the most important applications of the epicyclic bevel gear train. It enables the sliver or cotton fibre to be wound uniformly on the bobbin in cotton spinning, without breaking

Locomotive whistle invented by Stephenson.

1824.

Franklin Institute incorporated, March 30th. First course of instruction in mechanical science in the United States.

Compound engine constructed by James P. Allaire for the steamboat Henry Eckford, but was not a success mainly because it operated only at 25 pounds pressure.

Arago discovered that a magnet needle could be made to rotate by rotating a metallic plate placed under it. This was the first demonstration of electro-magnetic induction.

Sturgeon discovered the electro magnet, but in a very crude form.

Printing press introduced by David Napier which had nippers for holding the sheet of paper upon the rotating impression cylinder. It was thus an improvement upon Koenig's press (1811).

J. Clement, England, built a planing machine, the forerunner of present type. The tool was stationary and mounted on a cross slide, and was double-acting, cutting on forward and return strokes. Bed was carried on rollers. Was still running in 1876.

1825.

First passenger car, the "Experiment," used in England .

1826.

Tramway built from granite quarries of Quincy, Mass., a distance of 3 miles to tide water.

Patent leather was made about this time by Seth Boyden, in Newark.

Power loom for weaving wire by John S. Gustin, New York.

Fan blower introduced under the grates of the boilers in the steamboat "North America."

Printers' composition rollers for inking introduced into U. S. Used by Bacon and Donkin, London, in 1816.

John Goulding made the greatest improvement in wool carding by producing a machine which would turn out the endless roll or sliver.

John Davidson invented a shearing machine for woolen cloth. It had two blades, one vibrating, the other stationary.

1827.

Mauch Chunk Railroad, 9 miles long, built for the transportation of coal.

Hudson & Mohawk Railroad built between Albany and Schenectady.

Ohm demonstrated the principle which governs the flow of electric currents in circuits. Ohm's law is the foundation of electrical science.

The first "Fourdrinier" paper machine to be brought to America was started at Saugerties, N. Y.

Hackworth, England, produced the locomotive "Royal George," which had direct connection between cylinders and wheels, without the intervention of gears or levers.

Drop forging believed to have been first practiced at Harper's Ferry by J. H. Hall.

Joseph Clement, England, built a lathe at the works of Joseph Bramah, in which the spindle had variable speed depending on position of the cross-slide, thus adapting its rate of revolution to diameter of work.

Practical mortising and tenoning machine invented by John McClentic.

1828.

Baltimore & Ohio Railroad built.

Premium to Seth Boyden, of Newark, at exhibition of Franklin Institute for exhibits of malleable cast iron, the first of this material. His process not patented until 1831.

William Woodworth's planing, tongueing and grooving machine patented.

The Daniells wood planer also developed about this time.

Harrison Gray Dyer, New York, invented the chemical telegraph, an arrangement in which the electric current passes through a chemically prepared paper and develops colored lines or dots on it.

Ring spinning by which a light steel hoop or traveler running on the upper edge of a ring surrounding the spindle takes the place of the flyer, patented by John Thorpe.

Adams printing press invented. This press proved popular for fine work and an occasional one is still found in use (1900). The impression is taken by raising the bed upon which the type rests, against a stationary platen. This was the last of the large platen presses. It delivered the sheet after printing.

Joseph Clement, England, originated the system of fluted taps with number of threads in proportion to tap diameters. He fluted the taps with a revolving cutter.

John Ericsson built a surface condenser for a marine vessel, which was not successful, owing to a misconception of the conditions to be met.

1829.

John W. Revere explained his invention of galvanized iron at Lyceum of Natural History, England.

Manufacture of sewing silk by machinery commenced at Mansfield.

Joseph Henry, Albany, N. Y., produced an improved electro magnet in which insulated wire was used for the first time.

George Stephenson's "Rocket" successfully competed in a speed trial on the newly constructed Liverpool and Manchester Railway, traveling over 24 miles an hour.

Locomotive called the "Stourbridge Lion" built in England from plans of Horatio Allen, an American, and taken to America where it ran on the Carbondale R. R.

Peter Cooper, with the assistance of two mechanics, built a small experimental locomotive "Tom Thumb," that ran 18 miles an hour, drawing a load of 36 passengers.

James Nasmyth, England, invented the flexible shaft for drilling.

Timothy Hackworth, England, discovered the importance of the direct blast or blast pipe for locomotive. Claim, however, was disputed by others.

James Nasmyth made a milling machine for milling sides of hexagon nuts.

Remington Arms Company organized at Ilion, N. Y. First patent on Remington gun in 1863.

1830.

Crucible steel of best quality first made in quantity at Cincinnati Steel Works. Much inferior steel made earlier.

Centrifugal pump erected by a Mr. McCarty in the N. Y. Navy Yard, which resembled the modern pump.

The second American locomotive, the "Best Friend," built at the West Point foundry, New York, after plans by E. L. Miller. It had a common vertical boiler.

Lathe tools with inserted cutters very similar to those of the present time, in use in England.

Cramp's shipyard started in what is now Philadelphia.

A 22" engine lathe built by Nathaniel Wiley, Watertown, N. Y., having a rack feed. The rack was clamped to the carriage and driven by a stationary pinion in the head stock.

1831.

Cyrus H. McCormick built his first reaper for cutting grain of all kinds. It had the cutter bar, reel and other essential elements found on modern machines. Patented in 1834. Took gold medal at World's Fair, London, in 1851, where one of the machines cut twenty acres in a day.

Introduction of Howard's process of boiling in vacuum pan, after previous concentration in open kettles.

Joseph Henry constructed an electro magnet capable of lifting more than a ton of iron.

Improvements in platform scales were patented by Thaddeus Fairbanks and the Fairbanks Scale Works, St. Johnsbury, Vt., were founded.

Faraday's experiments this year developed the principles of electro-magnetic action.

Beginning of passenger railroad service. The "De Witt Clinton" built about this time for the Mohawk & Hudson R. R., which was typical of others. It had cylinders 5½ x 16 inches, weighed 3½ tons and pulled five coaches 30 miles an hour. The "York," successful on the Baltimore & Ohio R. R. These locomotives were inferior to English ones of which the "John Bull" was imported for the Camden & Amboy line and weighed seven tons. Horatio Allen suggested the swivel fore-end truck which was first applied on the Mohawk & Hudson R. R. by John B. Jervis.

1832.

Number of railroads completed and in progress at this time was 19; an aggregate of nearly 1,400 miles, upwards of 100 of which were already completed.

Machine for manufacturing pins, by John J. Howe, North Salem, N. Y. It formed the head of a coil of fine wire by dies, completing a pin at each turn of a crank, at the rate of 40 to 50 per minute.

Manufacture of table cutlery began.

M. W. Baldwin, Philadelphia, completed his first locomotive, called the "Ironsides."

Baron Schilling, Russia, invented a telegraph in which signals were given by the movement of magnet needles. Pixii, Paris, utilizing principles demonstrated by Faraday, constructed an electric motor.

Stop motion for drawing frames, used in cotton spinning, invented by Batchelder. Egberts applied the principle of knitting by power.

The "Stephenson" link motion, probably invented by W. T. James, New York. Adopted by Rogers Locomotive Works, in 1849.

First passenger car used in America was a stage coach slightly enlarged, Pennsylvania.

One of the first planers run in the United States was set up in what is now the Builders' Iron Foundry, Providence, R. I.

Silver & Gay, North Chelmsford, Mass., established. Built their first planer in 1836. It would take work about 3½" by 3½" and had one flat way and one V-way. Platen driven by a chain.

1833.

A locomotive engine, the Pennsylvania, invented by Col. S. H. Long, built by M. W. Baldwin, Philadelphia. Said to run a mile in less than 1 minute and drew 32 tons at rate of 15 miles an hour.

Beginning of new era in manufacture of iron with anthracite coal, through the introduction of the hot blast. Charcoal had previously been used.

First vessel to cross the Atlantic, propelled entirely by steam, was the Royal William, a Canadian steamship.

Gauss and Weber established a telegraph line about three miles long, at Gottingen.

Saxton made an electric motor. Improvement on Pixii's.

W. L. Wright applied a governor to a gas engine, in England.

The firm of Brown & Sharpe formed.

John Ericsson brought out his first caloric engine, but had made experimental engines on the same principle in 1827.

Obed Hussey patented a reaper which was for many years the chief rival of McCormick's, but lacked some of the features of the latter.

First typewriter in which separate keys were provided for each letter, patented in France.

Ross Weynans constructed three passenger cars with swiveling trucks; prototype of present car.

1834.

Three extensive shovel factories, one at Easton, one at Braintree and one at Bridgewater, owned at this time by Oliver Ames.

Wood screws made by machinery in Providence—the beginning of extensive screw manufacturing in that city.

Israel Coe, Anson Phelps and John Hungerford, pioneers in brass manufacture. A mill was started at Wolcottville, now Torrington, Conn. Brass had been rolled as early as 1811 in New York.

Professor Jacobi, St. Petersburg, Russia, constructed an electrically propelled boat, which ran on the Neva River and was capable of carrying ten passengers.

Prof. Henry constructed an improved motor.

Jacob Perkins, London, made the first compression ice machine that worked successfully with a volatile liquid.

The compensating gear for motor carriages appeared about this time, consisting of a set of epicyclic bevel gears.

The Washburn & Moen shops, Worcester, Mass., for the manufacture of wire, founded by Ichabod Washburn.

Richard Roberts, England, then of the firm Sharpe, Roberts & Co., adopted system of templets and gages in locomotive construction, to insure interchangeable work.

1835.

Fourteen locomotives built at Philadelphia by M. W. Baldwin; forty, the following year.

Manufacture of metallic or steel pens; Peregrine Williamson, New York. An improvement on his pen of 1809.

Morse began experiments on the telegraph.

Dr. Chas. G. Page, Salem, Mass., constructed an electric motor.

Putnam Machine Company, Fitchburg, Mass., started to manufacture machine tools. First lathe built in 1835-36; had rack feed, rack being attached to carriage and driven by pinion.

1836.

Manufacture of wrought-iron tubes and fittings for gas, steam and water works in the United States, at Pascal Iron Works, Philadelphia, by Morris, Tasker & Morris.

Coinage by steam power done in the United States Mint. The new coining press, designed by Franklin Peale was a very perfect piece of mechanism made with a toggle joint. Improved coin-milling machine carried by steam, invented and introduced in the United States Mint by Mr. Peale.

Some steamboat owners began experimenting with anthracite coal. Pine wood had been used for fuel in the past and, when on a route of six hours or more it was necessary to load the various decks with wood to keep up the supply.

Dr. John Frederick Daniell invented the double-liquid battery.

First practical revolver invented by Col. Samuel Colt. The cylinder revolved automatically when the hammer was cocked. Adapted to use metallic cartridges in 1873.

William Crompton, an Englishman, invented, at Taunton, Mass., a loom for patterns of goods that could not be woven on a cam loom. This was patented in 1837. The pattern was made up on a chain which controlled the harness to weave the proper figure.

First sleeping car run on the Cumberland Valley Railroad, Pa.

Smith, in England, and Ericsson, in the United States, simultaneously accomplished navigation by screw propulsion.

James Nasmyth invented or adapted the slotter to working of metals, being a modification of Maudsley's machine for mortising holes in wood. Another form of slotter invented by Nasmyth in the same year was similar to the modern keyseaters for cutting keyseats in the hubs of pulleys.

First locomotives with forged frames built by Coleman Sellers & Sons.

Crank driven shaper invented by James Nasmyth.

Band saws patented in the United States by B. Barker.

The Southwark Foundry and Machine Company established in Philadelphia.

1837.

First notable success in manufacture of pig iron from bituminous coal in three furnaces in Maryland.

Prof. Samuel F. B. Morse's numerous experiments with the electro-magnetic telegraph made public.

Manufacture of machinists' hand tools begun at Nashua, N. H., by John H. Gage; first devoted exclusively to that business.

First American patent for making India rubber boots, shoes, and overshoes by simply giving them a thin coating of gum granted to Stephen C. Smith, New York. During the next two years Charles Goodyear, of New York, obtained patents for making them wholly of that material, and introduced, under the name of vulcanized India rubber, an article in which caoutchouc was combined with sulphur and enabled to retain its elasticity at all temperatures, and withstand any heat short of the vulcanizing point.

Several telegraph lines were at this time in operation from Munich to near-by points.

Wheatstone invented a needle telegraph.

Morse exhibited his telegraph in New York.

Dr. Page discovered that a bar of iron, if rapidly magnetized and demagnetized, would produce a sound. This discovery may be regarded as the beginning of the telephone.

Steinhiel, Munich, discovered that the earth could be used as a return wire in telegraphing.

The "Sandusky," the first locomotive built by the Rogers Locomotive Works, Paterson, N. J.

Reversing or tumbler gear for engine lathes invented by James Nasmyth.

1838.

Howe Pin Mfg. Co., Birmingham, Conn., began manufacture of "solid headed pins" under a recent patent for a "rotary" pin machine obtained by J. J. Howe. Cost of production, one-third less than before, and it proved more economical to the consumer.

S. Hall used a surface condenser on S. S. Wilberforce.

Electro-plating discovered by Prof. Jacobi.

William Barnett patented the two-cycle gas engine in England and originated the flame method of ignition.

Steam used for heating sugar in refining.

The machine tools built by Bodmer, of England, between this date and 1841 had almost all the features of modern machine tools.

Milling machines used in Paterson, N. J., in which the work was fed to the cutter by set screws.

James Nasmyth invented the self-adjusting or spherical bearing for shafts.

David Bruce, New York, patented first entirely successful type-casting machine.

1839.

In this year Capt. John Ericsson came to the United States and superintended the building of the ship-of-war Princeton, provided with a screw propeller invented by him.

Henry Burden patented a machine for making the hook-head railroad spike. About this time, or a little earlier, he also invented an efficient horse-shoe machine.

Hancock's steam omnibus built in England. About this time several heavy steam wagons were used in England and then little improvement was made in automobiles until the era of light motor carriages in the latter part of the century.

Silver & Gay, North Chelmsford, Mass., made spur gear cutters previous to this date.

Joseph Whitworth built screw-driven planers before this date, cutting on both strokes.

William Fairbairn invented the steam riveter.

Babbitt metal patented by Isaac Babbitt.

1840.

Shepard & Co., of Buffalo, introduced the rotary valve with loose spindle for steam distribution. Later used by Corliss.

Hand-wheel and chain brake, similar to the common freight car brake, came into general use on trains.

Henry R. Worthington invented the direct-acting steam pump. It was used to feed a boiler on a steam canal boat designed by him. Boilers had previously been fed by a pump attached to the propelling engine, and when the boat was detained at the locks of the canal, it was necessary to use a hand pump. This suggested the desirability of an independent pump. This invention bears the same relation to pumping machinery that Corliss's does to steam engines.

About this time Col. Robert Hoe, New York, perfected his type-revolving press which made the rapid production of newspapers possible. The type was held on a large central cylinder, it being made to conform to the curvature of the cylinder by rules or "leads" thicker on one edge than on the other, placed between the lines of type. Impression cylinders were ranged around the type cylinder, and sheets were fed to these impression cylinders by operators. In 1850 a press having eight cylinders and requiring eight operators was built for the New York Sun, with a capacity of 8,000 complete sheets per hour.

About this time Samuel Cunard, Nova Scotia, established the Cunard Line, through English capital. This line held sway until about 1850, when the American Collins Line became successful.

First brass wire-drawing mill established by Edwin Hodges at Wolcottville, now Torrington, Conn.

A general change from oak to iron hulls for steam vessels.

About this time the automatic cut-off, with the cut-off and governor connected, is said to have been invented by Seth Boyden, Newark, N. J., but the invention was not developed.

The power loom, for weaving figured counterpanes, patented by Erastus B. Bigelow.

John Ericsson obtained a medal from the Mechanics' Institute, New York, for a design for a steam fire engine similar to one originally invented by John Braithwaite, an Englishman, in 1829.

Henry Pinkus obtained patent on an electric railway.

Wheatstone improved on his telegraph.

J. Gibbons patented a commercially successful seeding machine.

Slate & Brown. Windsor Locks, Conn., were regularly building planers driven by rack and spur gear.

Draft tube invented for turbine water wheels by A. & Z. Parker. The tube is placed below the wheel, and by its use the wheel can be raised above the bottom of the pit without sacrificing the head of water.

1841.

Joule demonstrated, experimentally, the relation between the electric current flowing in a circuit and the heat generated thereby.

S. Pennock made important improvements in cylinder drills for seeding, which revolutionized grain planting.

Silver & Gay made milling machines with feed in one direction only and with speed vertically adjustable. The milling machine at this time was known as the "slabbing machine," "whirl cutting" and "butt cutting" machine.

Robert L. Stevens designed the Stevens cut-off for marine engines. In 1842 he was commissioned by the Government to build an iron-plated floating battery, which was not completed at his death in 1856.

Joseph Bodmer, England, patented the reverse cones without steps for counter-shafts.

Important pumping plant built by Campbell's West Point foundry for the Brooklyn drydock. Pumps had previously been installed for the docks at Boston and Norfolk in 1832.

Machine patented by Samuel Slocum for sticking pins in papers.

Loring Coes patented a monkey wrench, Worcester, Mass.

1842.

Puddling came into general use in iron works, but was not entirely successful until the Burden squeezer was invented a few years later.

John A. Roebling began to introduce wire rope.

John Royle, Paterson, N. J., built looms for silk which were the first successfully operated.

The Arcade File Company organized in New York State and later moved to Anderson, Ind.

Walworth Manufacturing Company established for manufacturing fittings for steam and gas pipes.

The parts of guns and muskets formed with swages or dies at Chicopee Falls, Mass., by Albert Ames.

Emery wheels patented in England.

Splint-cutting machine for matches patented by Reuben Partridge.

1843.

Theodore R. Timby invented the revolving marine turret used later by Ericsson.

About this time Joule made his determination of the mechanical equivalent of heat.

Morse obtained from Congress an appropriation to construct a telegraph line from Washington to Baltimore.

Manila rope used for paper stock.

First American typewriter with separate keys patented by Charles Thurber, Worcester, Mass. Traveling carriage; keys and type carried by a rotating ring placed over the carriage.

1844.

First iron rails rolled in United States at Mt. Savage rolling mill, Maryland.

Morse telegraph from Washington to Baltimore constructed.

Uriah A. Boyden constructed turbine water wheels of the outward-flow type, patenting several improvements upon the Fourneyron turbines then being introduced from France.

First mowing machines as distinct from reapers. Previously machines were used for both purposes.

Little progress made in wood-working machines in this country until 1844, when there was started at Keene, N. H., a business that afterwards developed into the firm of C. B. Rogers & Co., Norwich, Conn., and J. A. Fay & Egan Company, Cincinnati, O. Finishing machines were made with wooden frames. These machines were so far improved in 1852 that, when exhibited at the Crystal Palace in London, they were considered superior to foreign-built machines.

1845.

One of the first uses of zinc in this country was in making standard weights for the Government in this year, through the efforts of Dr. Samuel Fowler, N. J.

J. W. Star, Cincinnati, O., invented the first incandescent lamp.

Faraday showed that all metals are not magnetizable.

Automatic arc lamp invented by Thomas Wright, London.

The first turret lathe is believed to have been built by Stephen Fitch, Middlefield, Conn. The turret head of this machine revolved on a horizontal axis.

Rolls used in wood-planing machines for holding the board in contact with the knives.

Machine for splitting and pointing shoe pegs patented by Stephen Baldwin.

Triger transmitted motive power by compressed air a distance of 750 feet at the mines of Challones.

An economizer for utilizing the heat in the waste gases of a boiler invented by Edward Green.

1846.

Centrifugal pump patented by William D. Andrews, New York.

Ingrain carpet loom patented by Bigelow.

Practical sewing machine invented by Elias Howe, combining the eye-pointed needle with shuttle for under thread, and automatic feed the length of the baster plate, and using a continuous thread. Previously short threads had been used or the cloth had been crimped into ridges for passage over the needle.

Taylor cylinder printing press manufactured with air buffers to absorb the momentum of the bed at the points of reversal.

Power loom adapted to weaving ingrain carpets by E. B. Bigelow.

Amasa Woolson brought out a rotary shearing machine for finishing cloth, with self-extension rest and having continuous feed.

Mason's self-acting mule patented for cotton spinning.

Thomas J. Sloane patented the gimlet pointed wood screw.

Improved form of drop forging machine for press work made by Albert Ames for E. Remington & Sons, Ilion, N. Y.

1847.

First steam gage made about this time by Sidney Smith, England.

Brussels and tapestry carpet loom patented by Bigelow.

Revolving disc harrow patented by G. Page.

Putnam Machine Company, Fitchburg, Mass., made their first gear cutter. Had iron frame.

James Nasmyth used an end mill for grooving shafts for keyseats.

1848.

Frederick E. Sickles designed and introduced the steam steering gear for vessels.

Telegraph cable laid between New York and Jersey City.

Practicability of rifling heavy ordnance demonstrated in Sweden.

Granulating machine introduced for drying damp sugar and reducing its grain.

The Schenectady Locomotive Works were erected.

The first automatic screw machine, but not of the turret order, designed by Newell North, Middletown, Conn.; perfected in 1852, and used to manufacture screws. The use for it was so limited that it was discarded.

The American Pin Company formed, which controlled patents of Howe & Slocum for sticking pins in papers.

James Nasmyth made punches for punching machines with slightly skewed faces to give shearing cut.

The firm of Bancroft & Sellers, now William Sellers & Co., established.

1849.

Union Iron Works, San Francisco, had its beginning.

The trip valve gear, combined with rotary valves, wristplates or rocker and dashpots introduced by George H. Corliss.

B-valve designed by Henry R. Worthington for pumps.

Nollet, Brussels, constructed a large electro-magnetic machine since known as the Alliance, which was used for years to operate arc lamps in lighthouses.

Sewing machine invented by J. Bachelder for two or more threads; had chain stitch, continuous feeding, horizontal table and overhanging arm.

Knitting machines became practicable through the use of the latch needle.

Joule demonstrated that heat and work were interchangeable.

Drill press built by Robbins & Lawrence, Windsor, Vt., with quick return.

1850.

The American Collins line of transatlantic steamers was established with four American-built boats, the largest, finest and fastest in the world. They took much of the traffic from the Cunard line. These boats carried 17 pounds steam pressure. After several successful years this line met with disaster through accidents and the withdrawal of Government aid, and its ships were sailed by the Inman, now the American line.

Manufacture of seamless drawn tubes commenced by American Tube Works, Boston.

Introduction of mills for rolling beams. First I-beams rolled in 1860 by Peter Cooper at Trenton, N. J.

Steam fire engine constructed by the Latta Brothers, Cincinnatti.

Page constructed a motor, the largest up to that time, and estimated at three horse-power.

Edward Howard and A. L. Dennison began the manufacture of watches at Roxbury, Mass.

Dr. John Gorrie, New Orleans, experimented with the expansion of air to generate cold.

James B. Francis designed an improved inward-flow turbine at about this time.

About this time several patents were issued for attachments to reapers for raking the grain off the platform after it had been cut and reeled. One of the most important was that of Adams and Sylla, whose machine also had the jointed cutter bar, controlled for several years thereafter by the Aultmans.

First toggle-joint punches or presses made at Townshend, Mass., by Mr. Smith.

About this time the American File Works, Ramapo, N. Y., made the first attempt of importance to manufacture files by machinery in the United States.

Bevel-gear planer made by Silver & Gay. Had a wooden frame.

The manufacture of scales and rules begun by Brown & Sharpe. Their first graduating machine built.

1851.

William Kelly, Kentucky, used the pneumatic principle of Bessemer in a furnace and produced a fine grade of iron, but did not make steel. His invention anticipated Bessemer's and he was granted a patent. This invention did not include the development of the engineering features necessary for the success of an iron or steel plant, which were an important part of Bessemer's work.

Ruhmkorff perfected the induction coil.

First submarine cable between Dover and Calais laid across the British Channel.

A. B. Wilson invented a lock-stitch sewing machine with rotary hook carrying a bobbin and taking the place of the reciprocating shuttle.

Singer sewing machine patented.

Bourdon pressure gage introduced into this country by E. H. Ashcroft.

"Force feed" drills patented, for sowing seed.

The Gordon job printing press with a platen moving to and from the type patented in this year. This press still in extensive use.

Improved knitting machine invented by J. R. Ellis, Boston.

The hydraulic jack patented by R. Dudgeon.

William B. Bement and Gilbert A. Colby were the founders in this year of what is now Bement, Miles & Co.

Cubitt employed compressed air in sinking the piers of Rochester bridge.

1852.

Electric telegraph fire alarm introduced in Boston.

Law passed requiring makers of boiler plate to stamp their names on the sheets.

Ericsson attempted to propel a vessel with a hot-air engine having cylinders 14 feet in diameter, but it was a failure. Small Ericsson engines have since been successful and are still made.

The "four-motion feed" for sewing machines patented by A. W. Wilson. This is in principle the feed motion still used.

Moses G. Farmer devised a system of multiplex telegraphy.

1853.

The Creamer brake patented for railroad cars. It operated by a coiled spring that could be released from any point on the train.

Duplex telegraph system in which messages could be sent in opposite directions at the same time, devised by Dr. Wilhelm Gintl, Vienna.

H. L. Sweet patented a sewing machine and binder for hats.

The interrupted screw for breech mechanism of large guns, allowing the breech block to be withdrawn by giving it a partial turn, invented about this time.

One of the first motor carriages constructed in this country was that of J. K. Fisher, New York.

New York Central Railroad established by the consolidation of several other lines.

Introduction of the camel back locomotive with engineer's cab on the boiler and a long, sloping firebox.

1854.

Compound engine for steam vessels introduced by Randolph and Elder.

First merchant flouring mill at Minneapolis.

Surface condensation began to be common on steam vessels.

C. Miller patented a button-hole sewing machine.

Watches made on interchangeable plan on a large scale at Waltham, Mass. Machine-made watches distinctly an American development.

First iron-clads ever built and actually employed in war were three built in France.

The anti-friction bearing, mostly used on grindstones, patented by a Frenchman named Pomme.

1855.

The Greene trip valve gear, a modification of the Corliss principle, introduced.

Stark, Vienna, transmitted two messages in the same direction at the same time, through a single wire.

Holmes designed a magneto-electric machine to generate currents for lighthouse lamps.

Dr. Werner Siemens invented the Siemens shuttle armature for electrical machines.

Prof. Twining, New Haven, Conn., completed a compression ice machine in Cleveland, O. It used ether and was the beginning of the compression system of to-day.

Soda fiber used for paper stock.

Vacuum pan adopted for sugar refining. Its use was understood as early as 1813.

The first Worthington water works plant established at Savannah, Ga.

E. Horton & Sons, Windsor Locks, Conn., manufactured chucks. The screw lathe chuck invented by E. Horton.

Turret lathe built by Robbins & Lawrence, Windsor, Vt., for making gun nipples. The machine was designed by Fred. W. Howe and the turret revolved on a vertical axis. This firm has been succeeded by the present Jones & Lamson Company, Springfield, Vt.

Planers still generally in use driven by chains instead of the rack and pinion.

1856.

Direct-acting duplex pump invented by Henry R. Worthington. Idea suggested by the action of the Worthington double-plunger water meter also invented by him.

First patents granted Sir Henry Bessemer, London, for the manufacture of steel by decarbonizing cast iron by means of a blast of air forced through molten cast iron. The success of Bessemer's invention is due almost as much to the arrangement of the engineering details and to an improvement patented by Rob't F. Mushet, England, consisting of adding spiegeleisen to the charge, as to the pneumatic principle involved.

First patent for Siemens' gas furnace.

The inclined water tube for steam boilers first used by Stephen Wilcox.

Two shafts, 35½ feet long by 27½ inches diam., forged at Reading, Pa., with a 7-ton hammer.

About this time J. E. Emerson, Trenton, N. J., introduced inserted-tooth saws.

Lieut. Dahlgren, U. S. N., produced a gun for firing hollow projectiles, which were of cast-iron and had the peculiarity that the thickness of the metal varied as the strains within the gun, being greatest at the breech.

Steam stamp for ore invented by William Ball, Chicopee, Mass.

Woodruff's sleeping car patented.

First armor plate appears to have been rolled in England at the Parkgate Works.

The shaft of Marie colliery was sunk by compressed air by the Societe Cockerill.

Cold-rolled steel manufactured in this country by the firm of Jones and Lauth, and the process was perfected under Mr. Bernard Lauth.

George Esterly patented straddle-row two-horse corn cultivator.

1857.

Weighted pendulum governor, giving increased sensitiveness, invented by Chas. T. Porter.

The three-high rolling mill, introduced by John Fritz, revolutionized rail making.

First attempt to lay an Atlantic cable, which failed after the loss of about 500 miles of cable.

The Italians Barsanti and Matteucci patented a free piston gas engine which was the prototype of the engines more fully developed by Otto and Langen a few years later.

Check rower for planting corn without previously marking the rows made practical by Haworth Bros.

L. J. Knowles constructed and patented a drop-box mechanism for operating shuttle boxes for looms by means of cranks set at the extremes of their throw under the direction of a pattern chain.

First typewriter resembling the modern machine patented by S. W. Francis, N. Y. Had a key for each letter, type bars, arranged in a circle, letters striking in the center, and traveling carriage over the type bars. Ribbon used for inking. None made for sale.

The Silver & Gay Company received a gold medal at the Middlesex Mechanics' Association for a bevel gear planer.

First balanced slide valve applied to locomotives by John Gleason.

The Stiles & Parker Press Company established at Middletown, Conn., for the manufacture of sheet metal working machinery, drop presses and drop forgings. Absorbed in 1890 by the E. W. Bliss Company, Brooklyn, N. Y.

1858.

Great Eastern launched, for the purpose of carrying on trade between England and Australia. She was 680 feet long, displacement 32,160 tons. She was driven by propeller and paddle wheels. While a commercial failure, she accomplished the useful mission of laying the first Atlantic cable in 1866.

The attempt made this year at laying the Atlantic cable was

successful, but the insulation began to fail and within a month the cable was inoperative.

Cooper Union opened.

The manufacture of the Knowles steam pump commenced at Spencer, Mass.

Rotary hook for single thread sewing machines by James E. A. Gibbs. Origin of Wilcox & Gibbs machine.

The absorption ice machine proposed by Ferdinand Carré, France.

The Marsh harvester patented; arranged to carry two men to bind the grain.

Machine for automatically knitting full-fashioned underwear by E. E. Kilbourne.

E. W. Brown patented the double reverse motion for looms by which shuttle boxes could be moved in either direction under control of a cam.

The Law shingle and heading machine patented, in which the saws entered the side of the block instead of the end, and the swinging carriage was used.

Henry D. Stone of the Robbins & Lawrence Company patented a turret lathe with self-revolving turret.

1859.

Hackworth's radial valve gear for steam engines introduced.

Independent circulating pump used for the condenser of S. S. Moulton.

John F. Allen invented a valve gear having a variable cut-off with positive movement, and introduced the multiport principle, and in 1863 made it a balanced valve.

Surface condensers began to come into general use.

First practical storage battery by Gaston Plante.

American Watch Co., at Waltham, Mass., organized.

P. H. and F. M. Roots invented the Roots pressure rotary blower, the first of the two-impeller type.

Petroleum discovered in the United States.

First milling machines used at Browne & Sharpe's in the manufacture of Wilcox & Gibbs sewing machines.

Warren Warner, founder of the Warren Elevator Co., Cincinnati, built a hydraulic elevator of the plunger type.

1860.

Manufacturers of crucible cast steel established on a firm basis.

Chas. T. Porter employed the inventions of Mr. Allen (1859) to make a high-speed engine with automatic cut-off. This was the beginning of high-speed engine practice.

Isochronous spring governor, invented by Chas. T. Porter. It had a spring with initial tension so as to exert a resistance which varied directly as the diameter of the circle described by the balls.

First indicator in which the motion of the piston was multiplied, invented by Chas. B. Richards.

Compound screw engines, adopted in 1854, became general.

The injector introduced by William Sellers & Co. Giffard, of France, is credited with the invention of the injector, he having deduced its theory in 1850. The first use of the injector on a locomotive in this country was on the Clarksville & Louisville road in 1860.

Electric machine with a ring armature, now known as the gramme armature, invented by Pacinotti.

Rev. Benj. F. Nice, Indiana, built several refrigerators for cold storage, ice being used.

Asa M. Swain designed and patented an inward-flow turbine with improved induct channels and an increased discharge area, which was the beginning of a new era in turbine water wheel construction.

The Rodman gun introduced; of cast iron, cooled from the inside by a stream of water flowing through a hollow in the bore, while the exterior was kept hot by the heated walls of a pit in which the mold was placed.

R. P. Parrott, of the West Point foundry, introduced a muzzle-loading rifle of cast iron, with wrought-iron rings shrunk on the breech.

Steam passenger elevator patented by E. G. Otis.

Centrifugal machine used in sugar refining for separating the syrup from crystallized sugar.

Monitor roof adopted for passenger cars, improving ventilation.

Worthington compound duplex pumping engine installed at pumping station, Greenwood Cemetery, N. Y.

Chain of railroads completed from Bangor, Me., to New Orleans.

Pratt & Whitney organized, for the manufacture of lathes, planers, drilling, milling and screw machines.

The knee type of milling machine introduced into America about this time.

Gage, Warner & Whitney, Nashua, N. H., built lathes having carriage-reversing mechanism in the apron. Also full automatic gear cutter previous to this year.

One of the first milling machines of the knee type imported from England, and bought by the Pettee Machine Company, Newton Upper Falls, Mass.

The manufacturers of wood-working machinery began to give their attention to iron frames.

1861.

Telephone that transmitted musical sounds but not speech, invented by Reiss, Germany.

Harrison's Australian ether machine the first ice machine adopted successfully for manufacturing. Used in England.

Dr. R. J. Gattling invented the machine gun consisting of a series of barrels which revolve about a central shaft and are loaded and fired in turn by automatic mechanism.

The Campbell cylinder printing press for country papers patented. This was adapted to the needs of country printers.

1862.

Ericsson's monitor launched. The financial success of the undertaking was due to John F. Winslow and John A. Griswold. Parts of the boat were built by different firms.

Phoenix wrought-iron columns invented by Samuel J. Reeves.

The McKay sewing machine for shoes came into use.

Alph. Beau de Rochas formulated the gas-engine cycle which goes by the name of Dr. Otto, who first put it into successful use.

Steam propelled fire engine constructed by Lee & Learned, in New York. One had been constructed in England about 1840. Later steam-propelled fire-engines were manufactured by the Manchester (N. H.) Locomotive Works.

Feathering paddle wheels made a success by Manley.

Holly system adopted for maintaining the pressure in water mains when connected with pumping engines by which the speed of the engines is regulated by the water pressure.

First milling machine built by Brown & Sharpe and sold to the Providence Tool Company.

The universal milling machine built by J. R. Brown, of the firm of Brown & Sharpe.

1863

The Lamb knitting machine patented.

Otto and Langen patented, in Germany, their free-piston gas engine, which established gas engines on a firm commercial basis.

First Pullman sleeping car, the "Pioneer."

About this time the modern perfecting press was introduced, in which papers are printed from the continuous roll by passing between cylinders on which are stereotyped plates. Previously, printing had been mainly from the type, the process of stereotyping being too slow for newspaper work. Improvements in stereotyping made the modern perfecting press possible. R. Hoe & Co., N. Y., were pioneers in these machines. The first patent for a self-feed perfecting press, however, was taken out by Bullock in this year.

1864.

First Bessemer steel made in U. S. by Wm. F. Durfee, Wyandotte, by a company who controlled the Kelly (1851) and Mushet (1856) patents. The Bessemer were acquired by another firm and in 1866 all the American patents on the process were consolidated, and the business was rapidly extended.

Elgin Watch Co., Elgin, Ill., organized.

Railway mail car introduced.

Milling cutter which can be sharpened without changing its form patented by Brown & Sharpe.

The Morse straight-lipped increased twist drill patented.

The Franklin Institute or Sellers Standard threads recommended for adoption.

1865.

First sectional water-tube boiler with inclined tubes made by one Twibill.

First sheet zinc mill in America erected at Bethlehem, Pa., by the Penn & Lehigh Zinc Co.

A. H. Brainard invented the Union bench vise, the manufacture of which had an important influence on the development of the milling machine by him.

Lallemont, an employe of Michaux, exhibited at Paris a bicycle or velocipede which resembled the form of the modern safety, but it was of wood and the cranks were on the front axle. He came to America and built a wheel in New Haven, taking out a patent in the names of Lallemont and Carrol. This was the only wheel of importance previous to the high steel wheels (1878).

The second Atlantic cable was laid by the Great Eastern but broke after about two thirds had been run out.

About this time the Nicholson File Company, Providence, was organized

1866.

A new company formed under the persistent work of Cyrus W. Field, to lay an Atlantic cable. The cable was laid by the Great Eastern, and this time was successful.

Small magneto machine, constructed by Wilde, magnetized the field of a much larger machine and the armature of the latter developed a current far greater than any before.

Pneumatically driven rock drills used on the Hoosac tunnel, Mass. This was one of the most important early applications of compressed air and between this time and the adoption of the pneumatic hammer, the rock drill, pneumatic hoist and air brake were the principle compressed air appliances.

Mitchell's consolidation locomotive brought out by the Baldwin Locomotive Works for the Lehigh Valley Railroad.

During this and succeeding years patents were issued to J. A. Fay & Co. and George B. Farrar for iron-frame timber dressers and molders with pressure bars on each side of the cutting heads, for working on four sides.

Winchester Repeating Arms Company organized at Hartford Conn., through the consolidation of several companies.

1867.

First Siemens gas furnace introduced regularly in the U. S. by J. A. Griswold & Co., as a heating furnace for a rolling mill.

First steel rails rolled (commercially) by the Cambria Iron Co., Johnstown.

Pennsylvania Steel Co., Steelton, first to produce Bessemer steel as a commercial article under the consolidated Kelly, Mushet and Bessemer patents.

Wheatstone and Siemens independently discovered that a portion of the current of the large armature will magnetize the field, and Wilde's small machine could be discarded. This was the beginning of the dynamo-electric machine, or electric generator.

Miller's platform and buffer for passenger cars first used.

The Mogul engine proper, built by the Baldwin Locomotive Works.

1868.

First open-hearth furnace, Siemens-Martin process, used by the N. J. Iron & Steel Co. The first patent for the combination of the Siemens reverbatory gas furnace and the Martin open-hearth was issued in France in 1865.

The Wampanoag, a war vessel designed by Isherwood, made a record of nearly 17 knots for 36 hours in a rough sea. Having a wooden hull, geared engines were used. This vessel and others of her class were the fastest afloat, either naval or merchant.

First practical typewriter invented by C. L. Sholes, Milwaukee, and patented by him, C. Glidden and S. W. Soule. Similar to the Francis machine (1857) but improved in details. In 1873 Remington & Sons, fire-arms manufacturers, Ilion, N. Y., became connected with the invention and after improving it placed it on the market as the Remington typewriter. One of their later improvements was the shift key by which twice as many characters can be printed as there are keys (1878).

Rubber tires for vehicles suggested by C. K. Bradford, an American.

J. D. Whitney, Brattleboro, Vt., made first inclined adjustable punching press. Is thought to be first maker of sectional dies and punches in United States.

Flather & Co., Nashua, N. H., builders of machine tools, started in business. Were the first builders to put on the market lathes with large hollow spindles.

Grinding lathe for grinding paper calender rolls, which would grind within one twenty-thousandth part of an inch, perfected by J. Morton Poole.

1869.

Westinghouse air brake patented. First tried on the Panhandle road.

Ground wood used for paper stock.

Junction of the Union Pacific with the Central Pacific, completing the first trans-continental railway.

Billings & Spencer Company, organized for the manufacture of sporting arms, but in 1870 took up drop forging, and have been actively identified in bringing that industry, which was then undeveloped, up to its present advanced and important position.

Spring tooth harrow patented.

1870.

Oliver chilled plow introduced.

Gramme, Paris, invented a dynamo-electric machine in which he used a ring armature.

About this time coal barges were unloaded by steam hoists at Jersey City, N. J.

The first Voelter pulp grinder was built at Watertown, N. Y.

About this time there were improvements leading to a marked increase in the speed of spindles of spinning machinery.

Polariscope used in this country in sugar refining—a French invention.

Richard Roberts, Manchester, built planer operated by a chain.

The Richardson pop safety valve invented about this time.

Sand blast invented.

1871.

Goodyear welt sewing machine, for shoes, patented.

The first "spring wet paper machine" built at Watertown, N. Y. The wet machine changes pulp from its fluid state into a solid state.

The Parkhurst wire-feed mechanism for screw machines patented.

1872.

First elevated road completed on Greenwich St., New York. Operated by a chain.

John C. Hoadley applied the balanced-spring shaft governor. It controlled the throw of a single piston valve in an automatic cut-off engine by moving eccentric across the shaft and giving constant lead but variable cut-off release and compression. This was the beginning of the high-speed automatic engine with shaft governor.

Duplex telegraph invented by Joseph B. Stearns, Boston.

The middlings purifier for flour mills introduced. Invented in Austria about 1830.

Brayton patented his gas and petroleum engine in America. It was not a success, but was the first American gas engine.

Wm. D. Ewart, Iowa, invented an improved form of link belt for use with sprocket wheels in driving the parts of reapers. Beginning of this form of power transmission on an important scale.

Automatic railway for handling coal patented by C. W. Hunt. The empty car was returned automatically by the weight of the loaded car.

Hay carrier patented by J. E. Porter.

L. J. Knowles placed on the market a loom embodying his box motion (1857) in connection with an "open shed" harness motion.

Beginning of use of band saws of large size in this country for sawing timber.

1873.

Cable road established at San Francisco

Dynamo-electric machine with a drum armature invented by Siemens and Alternack, Berlin. This type is now called a drum armature.

Hippolyte Fontaine discovered that power can be transmitted to a distance by electric currents.

John Humphrey, Keene, N. H., made improvements in turbines with enlarged escape area and in the use of turbines under varying heads.

The breech-loading Springfield rifle, developed at the Springfield, Mass., armory, adopted for the U. S. army.

The first standard journals adopted for car axles by the Master Car Builders' Association.

Westinghouse air brake made automatic.

Janney car coupler patented.

The Westcott Chuck Company, Oneida, N. Y., organized under the firm name of The Oneida Steam Engine and Foundry Company. This firm developed the first combination scroll chuck.

First Corliss pumping engine with a series of high-pressure cylinders ranged around a vertical shaft installed at Providence, R. I.

1874.

A. C. Kirk introduced triple expansion in S. S. Propontis.

Barbed wire manufacturing began at De Kalb, Ill.

Edison invented the quadruplex telegraph.

First commercially successful self-binders and reapers using twine. First patent was by John E. Heath, in 1850; but the most important patents were those of Bethel, in 1864; Locke, in 1873; and Gorham, in 1874; which last was the most successful.

Friction shaper in which the motion of the ram is obtained through friction clutches invented by E. J. Manville and manufactured by the Hendey Machine Company.

1875.

The "Thompson" steam engine indicator patented by J. W. Thompson, the first strictly modern design.

About this time E. D. Leavitt began the designing of the Calumet and Hecla mining plant, which includes engines of over 55,000 H.P.

Experiments with incandescent lamps made by Konn, Bouliguine, and by Lodyguin, of St. Petersburg.

Moses G. Farmer, Boston, invented a dynamo-electric machine.

Original Linde ice machine.

The curtain block signal for railroads adopted on the Pennsylvania.

1876.

1,400 H.P. vertical Corliss beam engine exhibited at the Centennial. Two cylinders, 40x120 inches. Revolutions per minute, 36.

Charles F. Brush, Cleveland, invented a dynamo-electric machine.

Prof. Graham Bell invented the telephone.

Arc light operating without mechanism, called the "Jablochkoff candle," invented by Jablochkoff, a Russian.

Chilled-iron and porcelain rolls for flour mills introduced, a great improvement in this industry. First used in Budapest, in 1874.

The Otto "silent" gas engine made its appearance and controlled the field for several years.

John B. McCormick constructed the "Hercules" turbine water wheel to use about double the quantity of water then common with wheels of like size. It was the prototype of several other "great power for diameter" wheels.

About this time C. W. Hunt introduced the steam coal shovel.

Saxly & Farmer interlocking system for railroads exhibited at the Exposition and marked the beginning of the use of the interlocking system in this country.

Large bevel gear planer exhibited by Corliss at Centennial Exhibition, Philadelphia.

Steam plunger feed for saw mills, patented by De Witt C. Prescott.

About this time the first laboratory in mechanical engineering was organized at the Massachusetts Institute Technology, Boston.

The Gleason half automatic bevel gear planer brought out this year and made entirely automatic in 1894.

1877.

Phonograph invented by Thos. A. Edison.

Small electric light invented by Edison; not successful.

The Brush, Wallace Farmer, Weston and several other arc lights were introduced about this time.

The Wooten firebox, a modified form of the wide firebox, designed for burning fine anthracite fuel, introduced.

The universal grinding machine patented by J. R. Brown.

Mekarski used compressed air for driving tramway cars, at Vienna.

Pneumatic hammer patented by S. W. Dennis, but not on a practical basis until several years later.

1878.

Hydraulic elevator installed in Boreel Building, New York. Worthington direct-acting compound pump, and plunger with multiplying pulleys.

Mild steel began to displace iron in steamship construction.

The second pumping engine erected by Geo. H. Corliss was at Pawtucket, R. I., and operated on only 13.6 pounds of steam per H. P. hour. It was a compound engine, jacketed.

Microphone, or carbon transmitter, now universally used in telephones, invented by Prof. Hughes, England.

Self-centering spindle for spinning machinery patented by F. J. Rabbeth. The spindle finds its own center of gravity and can thus run much faster.

First Columbia bicycle of steel and iron with high front wheel.

Automatic sprinklers introduced about this time. Parmelee's was the first. Perforated pipes had previously been used.

George B. Grant, Boston, Mass., first started as a specialist in gearing, being the first manufacturer to carry a stock of ready-made gears.

Joseph P. Frizell, Boston, invented air compressing apparatus somewhat on the line of the old trompé that was used for creating a blast. A device differing somewhat from this had been invented by A. Balochi and A. Krahmass in 1855, and still another by Arthur in 1888.

Compound air compressors were used by Northcote, and had previously been used by Mekarski.

1879.

Centrifugal separator for cream first put into practical use.

E. D. Leavitt introduced the re-heating receiver on the Boston sewerage engines.

Sawyer, New York, invented an incandescent lamp.

Electric motors used in Germany, experimentally, for plowing.

Siemens exhibited a small electric railway capable of carrying 12 passengers.

Griscomb, in this country, Marcel Deprez, France and others made small electric motors.

James Atkinson, England, the first to use hot-tube ignition for gas engines.

The Emery-testing machine, of 800,000 pounds capacity, erected and accepted at the Watertown, Mass., arsenal.

Star bicycle with large wheel at the rear and ratchet pedal movement invented by G. W. Tressey.

The Fox trimmer invented, for the use of pattern makers and others, which shaves off end wooden pieces at any desired angle.

The first cash register built by the National Cash Register Company.

First distinctly American stoker patented by Murphy.

First open-side planers built by Detrick & Harvey Machine Company.

1880.

Electricity applied to metallurgy.

Prof. Graham Bell and Sumner Tainter devised a photophone by means of which sounds could be transmitted over a beam of light.

Carbon filament incandescent lamp invented by Edison. Sawyer, New York, and Swan, London, invented similar lamps at about the same time or a little later.

John C. De La Vergne installed a practical anhydrous ammonia compression ice machine in the Hermann Brewery, New York. In the same year Norman Selfe designed a practical ice machine in New South Wales.

The Pelton water wheel invented and patented by Lester A. Pelton. It is a jet wheel, for use under very high falls.

A rapid-fire gun for repelling torpedo-boat attacks built by Hotchkiss for the French government. Beginning of heavy rapid-fire guns.

The manufacture of modern steel guns projected for the army and navy. The first steel imported from Whitworth's Manchester. The Watervliet and Washington gun shops planned.

Starley & Suttons original safety bicycle, the "Rover" introduced.

Adjustable ball bearings for bicycles invented by William Brown, of England. The American patents acquired by the Overman Wheel Co. (1884). Ball bearings also used on Columbia Standard wheel about 1880.

Hammond typewriter invented, in which the characters are on a type wheel instead of on type bars. It was the first practical machine to have visible writing.

Messrs. Atwood, Stonington, Conn., made improvements in silk spinning machinery whereby the speed of the spindles was increased over 100 per cent.

Class K locomotive built with a deep firebox on top of the frame by the Pennsylvania Railroad.

Spencer automatic screw machine was brought out.

L. S. Starrett commenced making the well-known combination square for machinists' use. Starrett afterwards developed the process for graduating scales from hard unannealed steel.

First meeting of the American Society Mechanical Engineers.

1881.

Seventeen-ton steam hammer put into use by Park Bros. & Co., Pittsburg. Built by Bement, Miles & Co., Phila.

Westinghouse high-speed engine introduced.

Triple expansion in marine practice, introduced in 1874, became general.

The Faure storage battery, now used exclusively, appeared this year.

Electricity first used for lighting coal mines in England.

Marcel Deprez experimented on the electrical transmission of energy.

Reece button-hole sewing machine patented; one of the most successful, in which the needle moves around the button hole.

Leavitt compound pumping engines at Lynn ran on 16½ pounds water per H. P. per hour.

Compound engines general in marine work.

1882.

The Briggs system of pipe threads adopted in this country by Morris, Tasker & Co., Ltd.

First Edison lighting station started in Pearl St., New York. Alternating currents used on a very limited scale.

About this time locomotive cylinders were made from a single pattern for both sides of the engine.

Steel car axles generally used about this time.

First pumping engine of the Gaskill type designed to give high duty at a reasonable constructive cost.

First pneumatic hoist for shop use appears to have been installed at the Atlas Engine Works, Indianapolis, Ind.

1883.

Wire nail manufacture received an impetus by the backing afforded by the American Wire Nail Co., Ind. The first wire nails were made in New York, in 1851, by Wm. Hassall.

Contract was let to John Roach & Sons for the Dolphin, Atlanta, Boston and Chicago, the beginning of the new U. S. navy.

Much experimental work carried on in connection with electric railways.

Electric lighting made great headway.

Motors for driving small machinery began to come into use.

Dunbar's five-cylinder compound engine tried on the Boston and Albany Road, but proved a failure.

The Newton Machine Tool Works built the first heavy slab milling machine which was not a combination of planer and miller, for the Stearns Manufacturing Company, Erie, Pa.

The odontograph for laying gear teeth brought out by George B. Grant.

1884.

The use of "compensating cylinders," to enable a uniform pressure in a direct-acting pumping engine to be maintained against the water plunger, when using steam expansively, patented by Chas. C. Worthington.

Arc lighting industry developed greatly. There were central stations in nearly all the principal cities of this country. Incandescent lighting also grew at a rapid rate.

Numerous patents taken out on storage batteries. The alternating current system was slowly forging ahead.

Sulphite fiber used for paper stock.

The Caligraph typewriter invented by G. Y. N. Yost, in which the shift key was abolished and a key used for each character.

Hiram S. Maxim began to manufacture machine guns in England.

Lidgerwood cable way patented.

1885.

The "American" system of rope driving, in which one continuous rope is used, patented by the Dodge Manufacturing Company, Mishawaka, Ind.

Thomas basic steel process introduced into the United States.

The first regular self-propelling fire boat. It was the "Seth Low," of the Brooklyn Fire Department.

The Welsbach incandescent gas burner patented.

Marked increase in activity of stationary motors, and in the railway field. Much experimental work done in the electro-metallurgical field, especially in process of extracting aluminum from its ores.

Atkinson "differential" gas engine patented.

The first hydraulic pulp grinder built by D. T. Mills.

The Mergenthaler Linotype machine patented for setting type. This machine has a keyboard similar to a typewriter by which an operator can cause matrices or dies, containing impressions of the letters, to form themselves into a line from which a solid line of type is automatically cast of type metal by the machine. The machine then automatically distributes the matrices to their

proper places to be used again. This machine is now used in most large offices and takes the place of hand composition.

Air hoists used by H. D. Gordon, at that time master mechanic at the P. W. & B. R. R. shops, Wilmington, Del., for handling car wheels. This application of compressed air for hoists called general attention to its possibilities in railroad and machine shops.

Patent feed for lathes, whereby the rod and screw are connected and disconnected at will, brought out by Flather & Co., Nashua, N. H.

The Roney mechanical stoker patented.

1886.

Bethlehem Steel Company began negotiations with Sir Joseph Whitworth & Co., England, for the introduction of the Whitworth fluid compression process for making steel forgings. Among the machines built or introduced was a 14,000-ton hydraulic forging press operated by a 15,000 horse-power engine, which is the most powerful stationary engine in the world. This equipment was the beginning of the production of high carbon steel for armor, artillery, shafts, etc., having a high elastic limit and great ductility.

The Mannesmann process for rolling tubes introduced.

About 400 electric-lighting central stations in the United States. Electric motors more extensively used. Great progress of the electric railway.

Transmission of power agitated. A charter obtained for the Niagara Falls Power Transmission Company.

First Tabor molding machine built.

The Jones underfeed stoker for boilers patented.

Drop forging of copper commutator segments first successfully accomplished by the Billings & Spencer Company.

Standard tread adopted for car wheels.

Beginning of the use of air brakes on freight cars.

1887.

This year marked the beginning of use of electric street railway cars. First commercially successful road at Scranton, Pa. Twenty roads were in operation and about fifty more in process of construction. In several instances, storage batteries were used to operate the motors.

Alternating current lighting stations were being rapidly installed.

Linde's process for liquefying air by the "self-intensification" method described.

The "Victor" bicycle, first one made with the rear wheel driven by a chain.

Pullman vestibuled train operated. Vestibule suggested in 1857 and used on the Naugatuck Railroad.

Universal tool grinder for lathe and planer tools introduced by William Sellers & Co.

Standard contour automatic coupler adopted by Master Car Builders' Association.

The Ingersoll slab milling machine with cutters having inserted teeth brought out.

Differential cable drum for street railways to prevent wear of cable patented by John Walker.

1888.

Basic open-hearth process used by Carnegie, Phipps & Co., Homestead.

First commercial application of electric welding, the invention of Prof. Elihu Thompson.

Gasoline for the gas engine was first employed by E. W. & B. C. Van Duzen, Cincinnati.

Electrically driven traveling cranes began to be seen about this time. Their introduction and the introduction of electrically driven machine tools later made possible the heavy machine work seen at the end of the century.

The Sprague Company equipped all the street railways of Richmond, Va., with electric cars. This gave the railway motor a new impetus and its adoption increased very rapidly. The alternating current induction motor appeared this year.

First drop frame ladies' bicycle.

The Daimler motor vehicle patented in America. This was one of the earliest of the modern carriages, and was followed by the Duryea carriage in 1895 and later by the Winton, Stanley, Riker and others.

Webb's three-cylinder compound locomotive tried on the Pennsylvania Railroad.

Pressed steel began to displace wood in car construction.

Aluminum made on a large scale by the Pittsburg Reduction Company, who used the Hall process. Aluminum had previously been manufactured by several companies.

1889.

Coal-mining machinery operated by electric motors.

The electric elevator, previously experimented upon, rapidly introduced.

Pneumatic tire for bicycles introduced about this time, having been adapted to the purpose by Dunlop of Ireland. Brought to this country in 1890.

The Yost typewriter patented. First machine to abolish inking ribbon and print directly from the type.

Nickel steel introduced.

First Schenectady compound locomotive having an intercepting valve to allow high-pressure steam to be used in a low-pressure cylinder, designed by Pitkin. In this year also the first Baldwin Vauclain compound locomotive was built for the Baltimore and Ohio Railroad.

1890.

First armor plate treated by the Harvey process, which hardens or carbonizes the steel on its surface. The first patent for this was granted to Hayward A. Harvey in 1888.

The Almond flexible tubing described.

Plans for the Niagara Falls power transmission enterprise drawn up and work begun thereon.

Trolley roads were rapidly introduced and both the direct current and alternating systems of lighting reached enormous proportions.

Stationary motors and electric elevators were manufactured by numerous concerns.

The Otto gas engine patents having expired, gas-engine building was started by many firms in this country at about this time.

The Zalinski dynamite gun invented about this time.

Tobin bronze, phosphor bronze and other compositions of high tensile strength came into extensive use. Phosphor bronze was invented in 1871.

"Youth's Companion" web-perfecting printing press with shifting tympan on impression cylinders to prevent offsetting, introduced by C. B. Cottrell & Sons, Westerly, R. I. Made it possible to print magazine work at high speed from a roll of paper.

Peter Burlo, Boston, used wooden rims on a bicycle in place of the metal ones.

Tobin bronze and other compositions of high tensile strength came into extensive use. Phosphor bronze had been patented in 1871.

Whaleback steamers introduced on the great lakes.

Steel cars brought out by G. L. Harvey about this time.

Work commenced on the battleship Oregon and the swift cruiser Columbia.

The Detrick & Harvey open side planer brought out.

1891.

The 125-ton hammer, largest in the world, put into operation at South Bethlehem, Pa.

Tin and terne plates first made in this country.

George I. Rockwood first proposed the "high-ratio" or intermediate compound engine.

The Sieve bolter or sifter with gyratory motion (called the Plansichter) introduced for flour mills.

The process of making carborundum discovered by E. G. Acheson, Niagara Falls, N. Y.

The Northrop loom patented by J. H. Northrop.

The diamond frame for bicycles exhibited by the Humber Company, England.

The Hurlbut-Rogers cutting-off machine with variable speed drive brought out.

The Hartness flat turret lathe patented.

1892.

Central stations for lighting and for the operation of electric railways began, about this time, to use generators directly connected with the driving engine. The largest units then employed were about 2,000 horse-power.

Electrically-driven tools for the machine shop began to assume importance.

The Krag-Jorgensen rifle recommended for adoption in the United States Army. The magazine principle of this and similar arms was patented by American inventors in 1879.

The Hendey-Norton lathe patented, which contains a nest of gears for convenient use in thread cutting.

Multiple spindle drill with radially adjustable arms patented by Oehring; patent controlled by Pratt & Whitney and Baush Machine Tool Company.

1893.

Allis quadruple expansion engine of 2,000 H. P. exhibited at Chicago, cylinders 24", 40", 60", and 70" x 72". Sixty revolutions per minute.

The Dow steam turbine patented.

The storage battery came into use in conjunction with generators in central stations.

A Brown 5-inch segmental wire-wound gun successfully tested at Sandy Hook. First wire-wound gun made in this country by Woodbridge in 1850.

Columbia tube mill established at Hartford, Conn, for making cold drawn seamless tubes for bicycles. Previously most bicycle tubing had been imported.

League Cycle Company, Hartford, Conn., placed a chainless wheel on the market.

Baldwin's Columbian locomotive built with a deep and wide firebox carried on a pair of trailing wheels and the locomotive had a single pair of truck wheels ahead. This was the forerunner of the Atlantic type.

George Gorton Machine Company, Racine, Wis., organized for the manufacture of their special disc surface grinding machines.

1894.

The De Laval steam turbine, with expanding nozzles, patented in the United States.

Carpet sewing machine in which the stitching mechanism runs along an elevated track over the carpet, patented by the Singer Manufacturing Company.

1895.

The plant of the Niagara Falls Power Company was put into operation. The tunnel was constructed to supply water for 100,000 H. P. and the water wheel and generator units were of 5,000 H. P. each. The wheels were placed 150 feet below the surface and the generators, at the upper ends of their vertical shafts. The weight of each shaft and armature is 160,000 pounds, supported partly by a water cushion and partly by a step bearing. At this time there were also numerous other water power electrical transmission plants in the country.

The use of electrically driven tools became general and large portable tools with electric motors attached were built. The increase in the size of electric generators and steam engines called for machine tools of unusual size, both stationary and portable.

The American-built ships, "St. Paul" and "St. Louis" commenced running.

First vertical mill engine, 2,000 H. P., installed by the Rice & Sargent Engine Company, at New Bedford, Mass.

Calcium carbide manufactured by means of electricity.

Monster electric locomotives built by the Baltimore and Ohio Railroad to draw trains through the Baltimore tunnel. They were larger than any steam locomotive then in use and weighed over 100 tons.

Enclosed arc lamps extensively used; also electric motors and elevators. Alternating current motors used, mostly of the continuous current type.

Colt automatic machine gun brought out; Browning's patent.

John W. Graves and W. E. Anderson built a cotton press that produced a roundlap bale of great density, requiring no bagging or ties.

Tabor molding machine improved so that the expensive stripping plates could be abandoned.

Steel wheel centers adopted for locomotives about this time.

1896.

Ten thousand H. P. rolling mill engine completed by Mackintosh, Hemphill & Co., Pittsburg, for the Carnegie Steel Company.

Twenty-four hundred electric lighting stations about this time. More than 90% of street railways used electricity.

The Buffington-Crozier disappearing gun carriage introduced. Abandoned in 1900.

The first hydraulic wet paper machine built at Watertown, N. Y.

Twist drill with internal oil-pipe conduits used. Internally lubricated milling cutters brought out by the Newton Machine Tool Works.

The Schoen pressed steel car introduced about this time.

1897.

Over 200 water-power transmission plants in operation at this time, whose combined capacity was over 60,000 H. P.

Mileage of electric railroads estimated at nearly 15,000.

Electric motors introduced on the N. Y., N. H. and H. R. R.

Walker magnetic chuck introduced.

The Mauser pistol introduced, in which the recoil ejects the cartridge, loads and cocks. In 1900 the Colt pistol on a plan similar to this machine gun introduced.

Morrow coaster brake for bicycles introduced.

Marconi wireless telegraph operated successfully.

Fellows gear shaper brought out, in which gears of all sizes are cut by a single cutter that automatically forms its conjugate in the gear blank.

1898.

The floating machine shop Vulcan was fitted out for the United States Navy. The first distilling ship for the navy was also put into commission.

First Diesel motor exhibited in this country. In this engine, air is compressed to a point where it ignites a spray of petroleum.

Capacity of the New York Edison Lighting Company's plant over 20,000 H. P. Capital invested in the electrical industry about this time, estimated at over two thousand million dollars.

1899.

The Parsons steam turbine, patented in the United States in 1888, built in large sizes by the Westinghouse Machine Company.

Seven hundred and fifty H. P. gas engines built by the Westinghouse Machine Company.

Water-tube boilers were adopted for use in the navy.

The Oceanic placed in commission. First steamer to have a greater length and displacement than the Great Eastern.

The Tabor vibrator frame molding machine brought out.

1900.

Taylor White process for tempering tools introduced by the Bethlehem Steel Company.

The Elevated Roads of New York are being equipped electrically; the Metropolitan Railway Company is constructing a station with a capacity of 70,000 H. P. and will use direct-connected generators of about 7,000 H. P.

Water-power transmission plants are constantly increasing; in some of the latest, the distance of transmission has reached 85 miles, 30 and 40 miles being considered a moderate distance.

Printing presses now produced which print and fold 96,000 papers of 4, 6 or 8 pages in an hour.

Allis pumping engine at Chestnut Hill Reservoir, Boston, Mass., showed an economy of 10.34 pounds of steam per horse power per hour, this being the best record for the century of a commercial engine.

A successful fixed-knife planer which will work soft wood at the rate of 100 feet a minute patented by J. A. Fay & Egan Company.

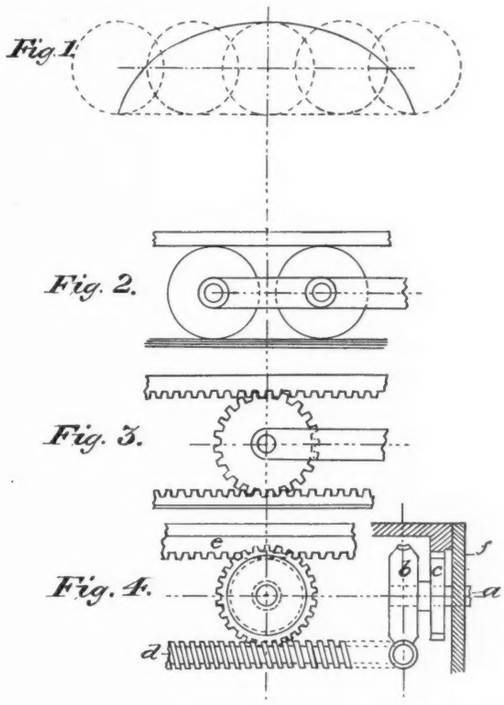
* * *

SOME DECEPTIVE MECHANICAL MOVEMENTS.

I. McKim Chase.

There are a number of mechanical movements seemingly paradoxical that are well known to not a few designers of machinery, but there are many such who are not familiar with their elucidation. A demonstration of these movements is a matter of difficulty even very frequently to some who understand them.

Although it is a well-established fact that the top of a wheel that may be rolling along a plane will move faster than the bottom, a debate will reveal that many persons, otherwise well informed in mechanics, are not aware of this. That the top really moves faster than does the bottom is clearly shown by the generation of the cycloidal curve Fig. 1. Here the movement of the point in the circle describing the curve begins at the bottom of the



circle at its meeting with the plane, and increases in velocity as the circle rolls along the plane until it attains the top of the circle. At this point the axis will have progressed one-half the circumference along the plane, and the describing point will have double the velocity of the axial movement. Instantaneous photography has also produced occult evidence to the same effect by showing the spokes of a moving wheel more strongly defined at bottom than at top.

Fig. 2 represents wheels or rollers resting on a plane, with a platform resting on the top of the wheels. If these should be given movement along the plane such movement will cause the platform to move with double the velocity that the axes of the wheels would have. Or, if the platform should be moved, thereby giving movement to the wheels, the axes of the latter will have one-half the velocity of the movement of the platform. Modifications of this movement are often made use of in mechanics.

Fig. 3 illustrates a modification of the foregoing. A pinion is made to gear into two racks, one of which is fixed in position,

the other being free to move between guides. A to-and-fro movement of the pinion will cause the free rack to have a reciprocating movement of double the velocity of the axis of the pinion.

Referring to Fig. 4, (a) is a shaft journaled to a traveling carriage; (b) is a wormwheel, and above it is a spur pinion (c), both of which are keyed to the shaft (a); (d) is a screw running lengthwise with the bed of the machine, and gearing with the wormwheel (b). Upon the opposite side of the machine from the screw (d), a rack (e) extends along the inside of the bed of the machine, to which it is secured. During operation the screw rotates the wormwheel, shaft and pinion, thereby causing the shaft (a) to advance, carrying with it the traveling carriage (f). Such an arrangement was designed in connection with an important and expensive machine used in gun-making, to provide a traveling carriage of a given velocity. But when the machine was put in motion, surprise was occasioned because the carriage moved with but one-half the speed intended, or one-half the pitch of the screw. Here is a case similar to that of Fig. 3, where motion is given to the pinion by movement of the rack, inasmuch as, so far as the resulting movement is concerned, the spur pinion may be eliminated, one side of the wormwheel supposed to engage the fixed rack and its opposite side engage the screw. In accounting for the phenomena of movements of this character, the wheels may be assumed to consist of an infinite number of levers rigidly connected at their centers, or the axis of the wheel. The fulcrums of the levers will be on the plane on which the wheel rolls, and for an infinitesimal space of time there will be no movement of the fulcrums. The axis of the system having a given movement, the ends of the levers opposite the fulcrums will have double the velocity of the axis.

Fig. 5 illustrates the Sun and Planet wheels. It is alleged that, in order to circumvent a patent on the crank as applied to the steam engine, Watt devised this movement to give rotary motion to the shafts of his engines. (a) is a spur wheel fixed to the end of the shaft; (b) is a similar wheel fixed to the end of the connecting rod, or pitman, as it was called. The wheel (b) is made to revolve around (a), thereby causing (a) to rotate at the rate of two revolutions for each single revolution of the wheel (b) around it, or one revolution of the shaft for each stroke of the engine. If the conditions are reversed the wheel (a), being fixed, and the wheel (b) allowed to rotate on its axis while revolving around (a), then the wheel (b) will make two revolutions on its axis in making one revolution around (a).

Some years ago the following question was asked the editor of a paper of scientific pretensions: "A and B are two wheels of like diameter; how many revolutions on its axis will the wheel (B) make in making one revolution around the wheel (A), the latter being stationary?" The answer given was, "One revolution." This answer evoked an almost interminable discussion. Some correspondents claimed that the wheel made two revolutions on its axis, while others held that it made but one. Persons equally informed in mechanics took opposite sides, correspondence came from nearly all parts of the earth ,and got so voluminous that a supplement entitled "The Wheel" was issued. The discussion was finally brought to a close by the paper reiterating its answer of "One revolution," and assuming to settle the matter by stating that if one of the wheels was turned at right angles to the other, like a pair of bevel wheels, it could be readily seen that one revolution was correct. The conditions of the problem were thus entirely changed to fit the answer provided. The question, as originally given, required both wheels to lie in the same plane, their axes being parallel with each other. When so placed, there is no possible doubt that the wheel (B) will make two revolutions on its axis, because the orbit described by its axis in making one revolution around (A) will equal twice the length of the circumference of (A). On the other hand, if the revolving wheel is at right angles to the one around whose periphery it revolves, but one revolution on its axis will be made, because the orbit described in making one revolution will equal the length of the circumference of the stationary wheel.

To many persons the most puzzling feature in this problem is: How is it possible for the revolving wheel to make more than one revolution on its axis when its circumference is just equal to that of the fixed wheel with which it is always in contact, the revolving wheel being a rigid mass? As previously stated, the reason can be best comprehended by considering the revolving wheel to be made up of an infinite number of levers, the fulcrums of which are at the point of contact of the wheels.

When investigating movements of this character, special attention to the movement of the axis of the revolving wheel is necessary to a clear understanding. In the case of the generation of the cycloidal curve (Fig. 1), the circle makes one revolution on its axis when the movement of the latter equals the length of the circumference of the circle, the curve described being greater than the movement of the axis.

In the case of the generation of the epicycloidal curve, Fig. 6, the two circles or wheels being of equal diameter, the length of the orbit described by the axis of the revolving wheel is twice

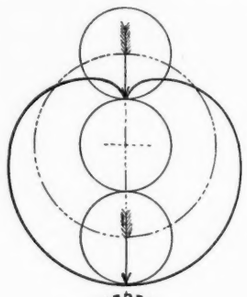


Fig. 6.

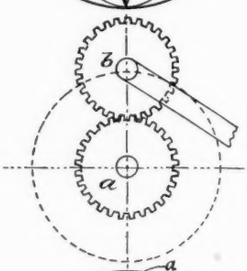


Fig. 5.

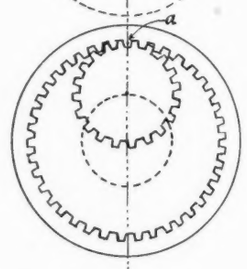


Fig. 7.

that of its circumference, and, consequently, two revolutions on its axis are made by the generating circle while making one revolution around the fixed circle. The movement of the axis of a revolving wheel, when in contact with a plane or curved surface, will always indicate the revolutions of the wheel on its axis.

Fig. 7 illustrates an internal gear wheel, and an ordinary spur pinion of one-half the diameter of the wheel. The pinion, in making one revolution around the wheel, will make but one revolution on its axis, because the length of orbit described by the axis in making the revolution equals the circumference of the wheel. A peculiarity of this movement is that a point, as (a), on the pitch circle of the pinion, will describe a straight line through the center of the wheel and back to its starting point with each revolution of the pinion. This produces a reciprocating movement which is sometimes employed in machinery. Another feature of internal gearing is that the movement of both wheels are in the same direction, while with external gearing the movements are in opposite directions.

* * *

The slip of paddle wheels is frequently double that of the screw propeller, but the efficiency of vessels fitted with the propeller does not appear to be due entirely to this cause. The speed of paddle wheel engines is necessarily slow, and they are therefore larger, heavier and costlier for a given power than propeller engines, which run at much higher speeds.

* * *

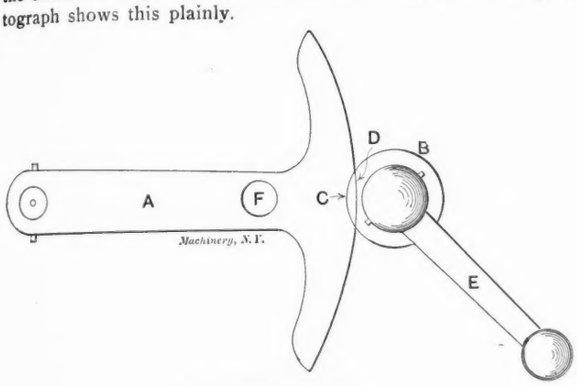
One cubic foot of water at the temperature of greatest density, 39° F., weighs 62.4245 pounds, commonly taken to be 62.5 pounds for ordinary calculations. At 210 F., one cubic foot of water weighs 59.82 pounds, or 2.6 pounds less.

LETTERS UPON PRACTICAL SUBJECTS.

ANENT THE GERMAN SAFETY DEVICE.

Editor MACHINERY:

We beg to call your attention to the safety device described in MACHINERY on page 72, November issue, which is used by J. E. Reineker, Chemnitz, Germany. We wish to call your attention to the fact that this device was patented in the United States a number of years ago by William Gleason, of the Gleason Tool Co., Rochester, N. Y., and is now owned and manufactured by us. We enclose a photograph which shows practically the same device on the apron of the carriage. You will notice that the quadrant has a portion of the periphery milled out on the same radius as the collar, which is on the shear-nut shaft, and this collar also has its periphery milled off on one side to fit the radius of the quadrant. In order to close the shear nut, the quadrant must be thrown down and the lateral feed gears thrown out of mesh before the collar will revolve; and to throw the lateral feed in, the shear nut must be open, which will allow the balance of the segment to pass by the collar at the point where the radius is milled off. The photograph shows this plainly.



Gleason Safety Device.

Our patent is No. 447,607 and was taken out March 3, 1891. We think it would be no more than right to call the attention of your readers to the fact that we hold a United States patent on this device, as it will avoid any confusion in the future. Our patent is, undoubtedly, much older than the German device which is probably a copy.

Allegheny, Pa. PITTSBURG MACHINE TOOL CO.

[Instead of reproducing the photograph we give herewith a sketch showing the idea more clearly. A is the quadrant lever referred to, with its handle at F. Its periphery is milled out at C to the same radius of the collar B on the shaft of the handle E. The collar B is also milled on its periphery, as shown at D, to the same radius as A. The action of the device is thus identical with that of the German device referred to.—EDITOR.]

* * *

AN ERROR OF CALCULATION.

Editor MACHINERY:

On page 93 of the November issue, I noticed a method for finding the volume of a wooden pattern. I admit that the method is very good, but I do not agree in the example that is given. It is stated that the pattern contains 1,050 cubic inches and "such a pattern, if cast without cores, would weigh in cast iron, $1050 \times .261 = 274.05$ ounces, or 17.12 pounds; in brass, $1050 \times .304 = 319.2$ ounces, or 19.95 pounds."

I think the above should be corrected to read: "Such a pattern, if cast without cores, would weigh in cast iron, $1050 \times .261 = 274.05$ pounds, or 4384.8 ounces; in brass, $1050 \times .304 = 319.2$ pounds, or 5107.2 ounces," because a cubic inch of cast iron weighs .261 of a pound and a cubic inch of brass weighs .304 of a pound. For convenience in estimating the weights of cast iron, it is roughly considered that a cubic inch weighs a quarter of a pound.

I send the above correction because apprentice boys who are ambitious read such articles as these, and for lack of a better knowledge of the subject are very liable to get a wrong impression.

Another approximate method of estimating the weight of a casting in cast iron is to weigh the pattern. Then if the pattern is solid, of wood and has no core prints, the casting will weigh sixteen times as much as the pattern.

It is generally considered that an ounce of pattern is equal to a pound of casting, but I have found this to vary, so that in some cases the casting has weighed as much as 19 times the weight of the pattern. H. D. VAN DOOM.

Providence, R. I.

[The statement made by our correspondent is, of course, correct. The calculation as given is self-evidently wrong and appears to have been made on the assumption that the weights of one cubic inch of iron and brass were in fractions of an ounce instead of pounds, as is the case.—EDITOR.]

* * *

SELLING MACHINE TOOLS.

Editor MACHINERY:

So Mr. I. Podunk thinks he can sell tools better or easier than the average salesman who tries to make customers believe that power can be gained by gears. When he has rounded up a few orders on his improved plan I am sure we will be glad to have him tell us all how he did it. In the meantime it may not be out of place to look into the conditions connected with the sale of tools. Are the men who buy tools any better informed about mechanical principles than the men who sell them? By the purchasers I now mean the men who do the choosing of the tools, not necessarily those who pay for them. I have had close relations with several men who bought tools for shops; some were proprietors and some were men trusted with the task, and I have also met many salesmen, and my firm opinion is that traveling salesmen have a higher average knowledge of mechanics than the men who buy of them.

Many proprietors of shops do their choosing of tools by a peculiar plan. When a tool is wanted they consult a little with their head mechanic, or write to several different places for quotations, after which along come the salesmen to see if there is any chance for them. When the proprietor has sifted till he has found the lowest price, he then tries to make his head mechanic believe that this is just the machine they want, and the latter, perhaps lacking a little backbone and fearing to raise serious objection lest no tool be bought at all, gives a qualified consent and the deed is done.

With such a buyer it is easy to see that no very brilliant mechanical knowledge on the part of the salesman is required, and he can work his "gain-power gear rig" on him or most any fairy tale invented for the occasion. In such cases it is sufficient for the salesman to make the buyer believe the tool offered is just as good as any other such tool made, and cheaper than any ever sold to anybody else. It is true there are some buyers who know just what they want and know how to buy it, but they are in the minority among the buyers. When the experienced salesman meets such a buyer he only needs to talk a few minutes with him to "know his man" and to understand at once that it is best to be honest with him and not pretend to know more about the tool than he is sure of. All traveling salesmen have better opportunities for gaining mechanical knowledge suited to their profession than the most of buyers have. They daily meet foremen, superintendents, inventors and proprietors, and often succeed in getting more information from employees than the proprietors themselves do. They become a sort of traveling encyclopedia specially adapted to their business. Of course, when work is behind orders, foundry hands off to a circus, hot wrist pin on the engine, steam roaring off at the safety valve and things wrong generally, it is very aggravating to have a drummer hanging around waiting to see you. But wait till another day when the men are at their places working like bees and the gratifying harmony of humming wheels and clicking hammers greets the ear, and the whole is moving like oiled clock work; then you will give the wayfaring salesman the glad hand and a cheery word, for you remember you want to ask him about something you have had in mind a week or more.

I doubt whether the training and knowledge required to make a good mechanic necessarily give any of the qualities

essential to a good salesman of machinery. Take such a mechanic, let him design a machine, follow its progress through the pattern shop, foundry and machine shop, then put it to test and act as wet nurse to it until all its faults and virtues are perfectly familiar, and he would actually be disqualified to go out and sell it. He would, of course, know better than to represent it as having gain-power gears and so forth, but he would also know a whole lot more about it, and though he may have worked up considerable confidence in the merits of the tool, he would have a haunting dread lest some one would ask a few leading questions directed at its weak points, and should the questions come he would soon be explaining and apologizing for its faults instead of presenting its merits. If the idea that a knowledge of mechanical principles would be a help to the salesman is correct, then the more thorough the knowledge is, the better.

One of the essentials to success in selling a tool is that the salesmen have abounding faith in it. It is a curious fact that an immense faith can be, and often is, based on a very small amount of knowledge. This is the most common and infectious kind of faith, and too much special knowledge is fatal to it, even in mechanical matters. A man thoroughly grounded in the principles of mechanics and also a good salesman is a "rare bird," and it may be that I. Podunk is one of them, but I fear for him. After he has met a few of the usual sort of buyers, to be found everywhere, I think he will conclude that making tools is a much easier and more joyful job for a mechanic than working his combination universal selling scheme.

BELL CRANK.

* * *

THRUST BEARING FOR LATHES—ONE THAT BROKE AND ONE THAT DIDN'T.

Editor MACHINERY:

At one stage of the never-to-be-forgotten apprenticeship of your humble servant, he found himself earning his $3.50 per by exercising the largest turret lathe in the shop—15-inch turret, 2-inch holes and a swing of 38 inches in the gap of the lathe. At that time—and it isn't as long ago as you might think from the decrease of hirsute growth on my cranium—this was a big turret lathe and as I recall the aches and pains of the undersized "cub" who ran it for 10 hours a day, it seems bigger yet.

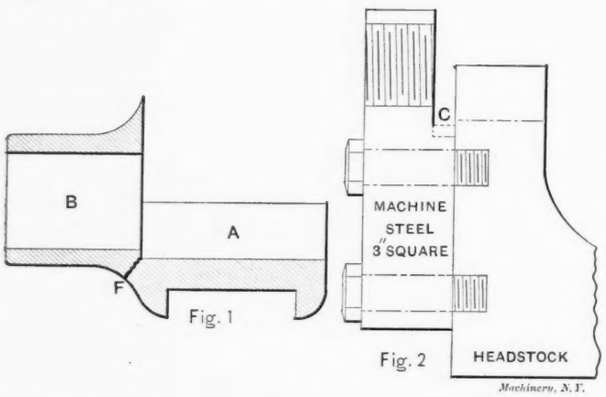


Fig. 1 Fig. 2

Machinery, N.Y.

Well, during the daily toyings with this machine I was surprised one day to feel the spindle give, and a thud—not very dull—proclaimed that something had dropped. This particular something was the thrust part of the box and the screw. When I saw how it was made (same as lots of others are being made to-day), I didn't blame it for breaking at F, as indicated in Fig 1. Any respectable piece of cast iron would let go under less provocation, and this seemed like an extra tough piece of metal.

The next thing to do was to get that lathe started again. It was needed in their business at that particular time as the Fox lathes depended on it for their work. I had visions of a three-legged stool arrangement with its spidery legs reaching each side of and below the spindle, but these didn't materialize as the foreman was a hard-headed Yankee who knew a thing or two in his line and enough to get along in several other lines as well.

He went to the stock room, picked up a piece of machine steel about 3 inches square (may be only 2½ inches) and had 8 inches of it cut off. Then the ends were ground off a little rounding, two holes were bored for ⅞-inch bolts, and it was turned over to the tool-maker to bore and thread the upper end for the thrust screw that was in B, Fig. 1. It was also counterbored at C, and formed a sort of cup to hold the thrust pieces and prevent their falling out. Then the piece was put in position, the place for bolt holes in headstock marked and a portable drill put in the holes in a hurry. We tapped them by hand and had the bolts all ready to put in, so it didn't take long to put it in place and have the lathe started once more.

Of course, care was taken to drill the holes and bore for the thrust screw as nearly square with the side next to headstock as possible, and it was not necessary to face this off, saving a little time in this way.

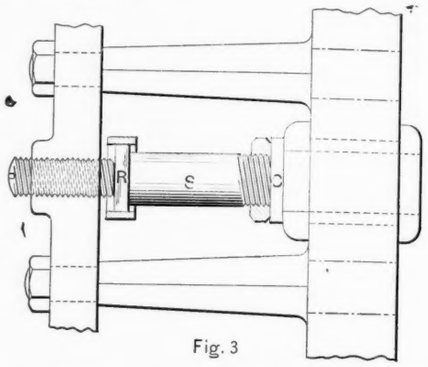


Fig. 3

Speaking about thrusts reminds me of one lathe we had—a Fox lathe—with a thrust as in Fig. 3. Two posts came back from the headstock and carried a cross bar which in turn held the screw for adjusting. A collar C took the wear in that direction, but this was, of course, light. Its main object was to prevent end motion in the spindle, which isn't a good thing in chasing threads with a bar.

The thrust piece R was one of our experiments. In this case it is a piece of rawhide held in a brass ring to keep it from spreading and also to prevent its dropping out if it wears slack—the extra width prevents this.

Rawhide does well in a case of this kind and lead is also good. If confined in a ring to prevent spreading as with the rawhide, its main difficulty disappears. It is a small part of a lathe but not an unimportant one at times. I. B. RICH.

* * *

HOW AN ENGINE LATHE WAS CONVERTED INTO A TURRET LATHE.

Editor MACHINERY:

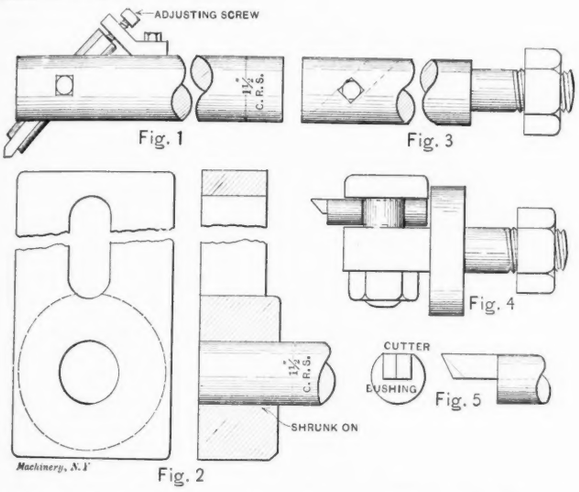
The importance of a good turret lathe for working up castings can hardly be appreciated by one who is not familiar with such tools, and my experience may come in handy to someone who is thinking of putting in such a tool. At any rate, he may get a hint or two on what not to do in some cases.

Originally our lathe was an 18-inch Prentice, extra heavy, with coarse feeds. Just the lathe for "taking it off at once." The turret was of the usual pattern, automatic, with the Warner & Swasey device for spacing the holes. It was made by a firm in Cincinnati. When the order was given for the turret an expert (?) called to make a templet of the lathe-bed and centers. He called for a sheet of tin and a pair of shears, and in short order had a templet (?) made that would have given any planer hand a "fit." It seemed, however, to suit him. After waiting a month we ventured to inquire if the machine had been shipped. In response the tool-building firm sent a request for a templet of the shears, and also requested that we fill out on a blue print which they sent the blank dimensions of the lathe. That time we made the templet, and after waiting almost two months longer, the long-looked-for turret arrived. Everything seemed to be O. K. until we placed the slide block on the shears. Somebody had been careless when they planed those vees, and as a consequence the turret rocked on the shears almost a thirty-second. We were in too big a hurry to send it back, and as we had no planer or shaper, it began

to look as though I was going to have a job very much like "Mr. Bowser's" when he attempted to level up the table with a hand-saw. We had in the meantime lined up the spindle with the aid of some candles stuck on a stick, and got it square and level with the shears. After a great deal of scraping we got the turret slide to travel in a line with the spindle also. We were now ready to bore the holes for the tools in the turret. This was accomplished by drilling them first with a twist drill held in the chuck, and afterwards boring them with a bar held in the same way. The tools we made were very efficient, though not graceful. Every man in the shop condemned them until they saw how they stood up to their work, and then he changed his tune.

The boring bars were made like Fig. 1, and the outside tools like Fig. 2. We made several of each pattern, and also made several tool posts like Fig. 3. We used 5-16-inch square Mushet steel for all cutters.

The manner of inserting the cutter is believed to be original. It has many advantages over the old-fashioned way of making a square hole in the bar. We simply drill and ream a 5/8 inch hole in the piece where we want to put the cutter, and then we take a piece of 5-8-inch cold-rolled steel and mill a slot in it, like a keyway, as shown at Fig. 5, large enough to contain the cutter. This bushing is case-hardened, and can be made to support the cutter along its entire length. The set screw bears directly on the cutter.



With the tool holders made as shown at Fig. 2 and the cutter posts like those in Figs. 3 and 4, we can do any job that can be held in a chuck. We make all facing cuts with the tool held in the slide rest on the carriage, as in an engine lathe. We have put a power feed on the turret, as it was next to impossible to feed it by hand on large work. This feed is very primitive, but it does its work in a first-class manner. It is simply a long hook that extends from the carriage to the turret slide. The carriage tows the turret.

When the lathe was first started to work it was found that the tools would not cut twice alike. The turret would not come around to the same place every time. Sometimes the variation would amount to three or four thousandths of an inch. We put a stronger spring behind the locking bar, but that did not help much, so we turned the tools up 90°, so that they cut directly over the centers. In that position three or four-thousandths to the right or left does not cut much of a figure. The work turned out now is right down to size, and the lathe and tools cause no trouble at all. The first cost of the tools was small, and the repair bill has not amounted to anything yet. It does not take much steel for cutters. When the longer ones get too short they can be used in the place of shorter ones. So much for using steel of the one size for all cutters.

Audubon, N. J. J. EDWARD BARRETT.

* * *

AN INCORRECT METHOD OF COMPOUND INDEXING.

Editor MACHINERY:

In the November number of MACHINERY, Mr. C. H. Marvin gives a method to index a 69-tooth gear with a 23 hole index circle, which is incorrect. He says to cut a tooth at every third hole, thus obtaining $23-3=7\ 2-3$ divisions each time around, and that nine times would give $9 \times 7\ 2-3 = 69$ teeth. He probably supposes that the 23 hole index plate goes directly on the spindle of the dividing head instead of on the worm shaft. As the worm shaft makes 40 turns to one of the spindle, using 3-23 movement would give a division of the spindle of $3\text{-}23 \times 1\text{-}40 = 3\text{-}920$. The number of divisions is the reciprocal of this, or $920\text{-}3 = 306\ 2\text{-}3$. But even if the index plate went directly on the spindle, he could not cut 69 teeth by this method, because a less number of times around than 9 would make a whole number of divisions. For example, $3 \times 7\ 2\text{-}3 = 23$, and after cutting 23 teeth, the next move would bring the cutter directly in the first space cut, and no more teeth could be cut, no matter how many times we indexed around the circle.

East Providence, R. I. JOHN T. GIDDINGS.

* * *

COMPOUND INDEXING TO CUT SIXTY-NINE TOOTH GEAR.

Editor MACHINERY:

Referring to the article of E. J. B. in the September issue of MACHINERY on gear-cutting without the proper index plate, I think the job could have been done more quickly and accurately by compounding the index plate.

Taking for example the number of teeth mentioned (69) we find by referring to B. & S. table that this can be divided by using circles 33 and 23. The moves would be $\frac{21}{23} - \frac{11}{33}$.

The operation is to first place the stop pin in the 33-hole circle and the index crank pin in the 23-hole circle; set your sector for 21 holes and move the index crank that distance in the desired direction. The crank is left in the 23-hole circle, the stop pin pressed back, and the index plate revolved 11 holes in the opposite direction. This will give the correct division.

W. J. D.

* * *

MORE ABOUT COMPOUND INDEXING.

Editor MACHINERY:

I notice in the September number of MACHINERY that E. J. B. has devised a method of cutting a 69-tooth gear without the proper index plate. I have just had the same problem in our shops and met it in the following way:

I have a milling machine with an index plate having, among others, a row of 39 holes on one side and 46 on the other. Putting the plate on with the index pin in the 46 row, I cut every third tooth around the blank as if cutting a 23-tooth gear. The plate is held from turning by a locking-pin so placed on the index head as to work in the 39 row of holes at the back of the plate. To get the next space it is necessary to turn the whole index plate through 40-69 of a turn. This is done by withdrawing the locking pin at the back and turning 26 holes ($2\text{-}3 = 26\text{-}39$). This $2\text{-}3 = 46\text{-}69$ and as 40-69 is the fraction through which we should turn our index crank, we have gone 6-69 or 2-23 or 4-46 too far and we turn back the 4-46 by locking at the back and turning the crank 4 holes backward on the 46 row where the index pin is already set. After cutting 23 teeth around the blank, as before, we again turn the plate ahead 26-39 by using the back locking pin, and backward 4-46 by using the regular index pin and cut around the blank again, thus finishing our 69 gear by cutting every third tooth each time, and going three times around the blank. Of course we could cut consecutive teeth by using the compound index each time, but it is easier and less liable to error if we use the double index only twice instead of 69 times. It is very convenient on odd jobs of indexing and does away with all cut-and-try methods.

Bozeman, Montana. J. H. GILL.

* * *

WHEN TO JIG AND WHEN NOT TO JIG.

Editor MACHINERY:

For the last few years the air in the vicinity of machine shops has been full of jigs and rumors of jigs. All well and good. Jigs are beautiful things in more than one sense, though occasionally quite ugly enough in appearance. There are some curious things in connection with the jig situation to-day. One

of these, and not the least interesting by any means, is the very different spirit in which different shops have taken up the question. It might almost be said of certain shops, "By their jigs ye shall know them," for shops operated upon good common sense principles will have sensible, practical tools; while those under an extravagant management will go to the extreme in the jig and fixture question, and lay out many dollars on tools that will never have an opportunity to earn interest on themselves. And some of the less progressive shops, with a rather conservative management, continue in some fashion or other to get along with no jigs at all; or if they happen to have a few, they are apt to be of more interest to the curiosity hunter than to the practical mechanic.

This all pertains to the policy of various managements and their idea of what ought to be allowed in the way of special tools. Now as to the tools themselves, one of the strangest things is that so few men seem able to lay them out in a way entirely satisfactory to any one else. Pattern makers all like jigs! Oh, don't they, though? And molders also! Then the toolmaker, doesn't he like to seek out the vulnerable spot in a jig design, and say that if he only had a little paper and time to use it he could lay out something that would knock that? And then the fellow that uses the jig; it may be that he has just started work and never handled a tool before in his life, but that doesn't make any difference, there are just so many things about that jig that ought to be changed. And so it goes. 'Twas ever thus since the first jig was made. Often criticism is deserved; sometimes it isn't. There are men whom any competent commission would pronounce incapable of using a twist drill, who yet consider themselves well fitted to pass judgment upon every machine or tool that comes in their direction, whether it be the product of our leading manufactories or merely the work of home talent. In a general way, however, criticism is a good thing and well calculated to keep one from gaining a too exalted opinion of himself.

It is pretty generally understood that the most important results from the use of jigs are, accuracy to the point of interchangeability, speed of production and cheapening of labor. There are many other considerations of somewhat less importance, but which cannot be overlooked when the question of "to jig or not to jig" arises. In looking around certain shops it seems as though the tool subject had been handled in a masterly manner and that the art of rapid production at comparatively low cost had been brought somewhere near perfection. It is in these places that jigs are made that are practical and mechanical; jigs that will locate a piece and after locating, hold it in such a manner that it can be drilled satisfactorily, and after drilling will admit of its being conveniently removed; jigs that are not mere chip baskets and catchers of dirt, but that do good work and lots of it every day in the week.

In these shops the jig-and-fixture idea is not carried to excess. Parts much in demand will warrant the expense incurred in the designing and making of a good set of tools. But where certain pieces are made in small quantities it is deemed more economical to let a skilled man make them than to go to the expense of getting out a complete set of fixtures which must necessarily be idle the greater part of the time. There are shops, however, where special tools are overworked. Every time a new line of work comes in, there is a loud cry for tools. No matter whether there is a possibility of making one thousand parts of a kind or merely half a dozen, jigs and fixtures must be had. Not a cut can be taken, not a hole drilled, and all things with the exception of the vocal organs are in a paralytic condition until those tools arrive. This is carrying a good thing so far that it proves a burden rather than a blessing.

N. W. Fay.

* * *

CHANGE GEARS FOR SCREW CUTTING.

Editor Machinery:

While most machinists are probably familiar with the conventional rule for finding the change gears for screw cutting, yet when they attempt to apply the rule to a lathe in which the stud for the gears runs at a different rate from the lathe spindle they find the rule does not work, as did a shopmate, who frankly said: "Whenever I try to figure change gears on a lathe of that kind I always get stuck." There is no necessity for anyone to get "stuck" on this account, however, as all it is necessary to do is to obtain an imaginary lead screw for the calculations and proceed as usual. To do this we could place two gears of the same number of teeth, one of each on the stud and lead screw, and use the number of threads per inch they will cut, for the required lead screw. Or, if there are not two gears just alike, as in a lathe I once came across, we could calculate the lead screw by the rule: "The number of threads per inch of the lead screw, times the number of teeth in the lead screw gear, equals the number of threads per inch to be cut times the number of teeth in the stud gear." The lathe mentioned was a Dexter lathe, and had a lead screw of four threads per inch; but to cut four threads per inch the gears required were 48 on the lead screw and 64 on the stud. Then (according to the rule) the lead screw would be $\frac{64 \times 4}{48} = \frac{256}{48}$ = 5 1-3 threads per inch.

For example: It is required to find the gears for 11 1-2 threads per inch to fit a standard pipe. Why 11 1-2 threads per inch were adopted for several sizes of standard pipes instead of 11 or 12 per inch has always been a mystery to me. The proportion for the change gears would be:

$$\frac{5\ 1\text{-}3}{11\ 1\text{-}2} = \frac{5\ 2\text{-}6}{11\ 3\text{-}6} = \frac{32 \text{ on stud}}{69 \text{ on screw}} = \text{gears required.}$$

These were not in the set, nor was twice or three times the number; so to find the nearest approximation among the set is the next thing in order. In this case we can multiply by 1⅛, as follows: $\frac{32 \times 1\frac{1}{8}}{69 \times 1\frac{1}{8}} = \frac{36}{77\frac{5}{8}} = \frac{36}{78}$ nearly. These gears are in the set.

It is desirable in a case like this to find what the error would be. As it was required to screw the pipe four threads by hand, it is obvious that a slight error in the pitch would not make much difference. Using the rule given, $\frac{78 \times 5\ 1\text{-}3}{36}$ = 11 5-9 threads per inch which the gears will cut. To get the pitch of one thread $\frac{1}{11\frac{1}{2}} = .0869$ and $\frac{1}{11\ 5\text{-}9} = \frac{9}{104} = .0865$ .0869 — .0865 = .0004 = error for 1 thread, and 4 × .0004 = .0016 = error in 4 threads, which is near enough for practical purposes, to make a tight joint. I observed a workman cutting an internal left-hand thread with his lathe spindle running backwards, and an inside thread tool bent around the opposite way from the common one. The workman said he learned his trade away up in the backwoods.

But this kink is a good one for the purpose, as one can watch the cut at the start and try in the sizer before cutting the whole length of the thread, if required, which cannot be done if the thread was cut the usual way, beginning at the inside of the threads and running out towards the tailstock.

East Providence, R. I. J. T. Giddings.

* * *

"TROUBLE WITH TAPS"—MAKING EMERY WHEELS FROM BROKEN ONES.

Editor Machinery:

"Trouble with taps," as described by "Hoosier" in your November issue, has occurred in my experience, and was overcome in this way. I noticed a new tap turned so hard that it was a wonder it was not broken at first use. An examination showed about 1-40″ of bright strip along the top of teeth, showing that amount of binding surface. Taking a small emery wheel and turning its edge to about the shape of the grooves in the tap, the face of the teeth was easily ground, holding the tap in the fingers below the wheel, where the grinding could be easily seen. This is no great trick and a little practice should enable almost anyone to do it successfully. It has often occurred to me as one of the machine shop anomalies, that taps are so seldom sharpened considering the severe work they do, and when they are ground it is most common to grind off the tops of the teeth, increasing the length of the taper, until that feature alone makes them turn extremely hard in a deep hole. But someone says, "I have no small emery wheel. That talk is well enough for him, but it don't do us any good." I would reply that almost any one who uses emery wheels has some broken ones which may be easily worked up into small wheels, and if using

wheels at all, he should have "a dresser" of some sort or a diamond, or both, to true and sharpen them with.

Taking a suitable sized piece of broken wheel, of proper grade, it may be broken into shape, roughly, over the edge of the anvil, with a chisel, somewhat as slate is cut; after which the hole is drilled, the breaking out round being the risky part. For drills I use a piece of soft round rod, hammering the end flat and spreading it to suitable size, thus giving side clearance. In drilling, run the drill slowly, using fair pressure so as to keep it cutting, and when dull hammer out again. It is surprising how fast this thing will drill in a Norton or vitrified wheel. To enlarge the hole to proper size, an old half-round file, used as a reamer, works quickly and well. Leading the center has no trick about it, except to scratch a groove around the center of the hole so the lead will not come out. The wheel can then be ground nearly round on any coarse emery wheel, then mounted and turned to shape with a diamond.

I do not advise making wheels in this way as a general practice, but sometimes the want of a wheel at short notice is when the trouble begins, and then the above plan may be of use.

Bennington, Vt. O. S. BEACH.

* * *

A "PULLER" FOR PLANER STOP BUSHINGS.

Editor MACHINERY:

The table of our planer, an old New Haven 42" x 42" x 16', has holes in it of the shape shown in Fig. 1. In these holes it is impossible to use stops having ground shanks so we have a number of cast-iron bushings to fit these holes. These bushings have a 1⅛" hole to fit our stops and are shaped as shown at D, Fig. 2. The holes in the planer table being cored, are not exactly the same size and consequently the bushings which are a nice fit for the larger holes are a driving fit for the smaller ones. We found it a difficult job to get these out, as it

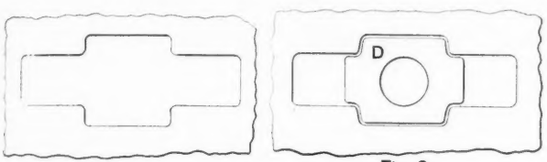


Fig. 1

Fig. 2

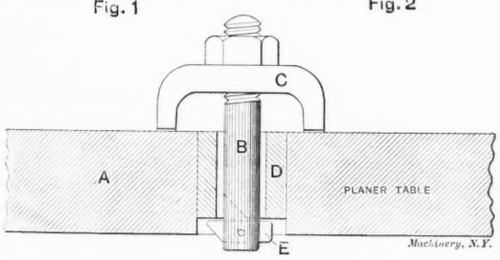


Fig. 3

was not always possible to drive them out from underneath. The man who runs the planer devised the tool shown in Fig. 3.

A is the planer table; B, the "puller"; C is a yoke and D is the bushing to be pulled. The puller is easily pushed down through the bushing, as the tongue piece E turns up into the groove indicated in the dotted lines. When it has passed through the bushing, the tongue falls by gravity into the position shown. One can then, with a few turns of the nut, easily remove the tightest bushing.

E. A. SUVERKROP.

Philadelphia, Pa.

* * *

A COUNTRY JOB.

Editor MACHINERY:

We once had a small job to do in which there were a great number of pieces required. These pieces were small cast-iron rollers to be used in an anti-friction bearing for the trunnions of a churn, two in each bearing and four to the churn. (See Fig. 1.) They were required to be finished on the small diameters and faced on the sides of the large part. The diameter of the large part was left as it came from the foundry, any projections being ground off. We used the drill press on this job, with the tool shown in Fig. 2. This tool was of tool steel drilled out in the center to the required size of the small diameter of the roller and faced to the bevel wanted, and teeth were filed in the face, thus making a kind of end mill of the tool. To hold the work we used a block and pair of tongs. The block was culled from the scrap heap, and had two parallel sides. In one side I drilled a hole big enough to take in the small part of the rough casting loosely, placing it vertically in the hole. The tongs were of flat section, the jaws being bent in a circle just big enough to clasp tightly the large diameter

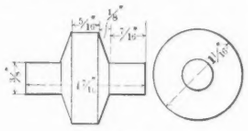


Fig. 1.

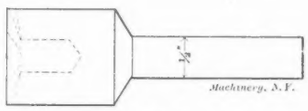


Fig. 2.

of the casting, and an ordinary link was used to hold the handles of the tongs together. The tool shown was held in the drill chuck. This method was possibly crude, but it was very effective and cheap, for I have turned out 27 and 28 sets, of four pieces each, in an hour. Cheapness and speed were the prime requisites in that shop.

E. J. H.

Washington, D. C.

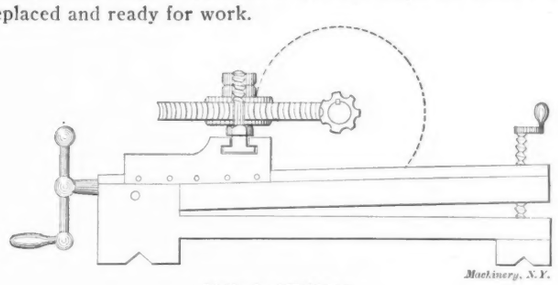
* * *

CUTTING A WORM GEAR, ETC.

Editor MACHINERY:

In making repairs to a bolt-cutting machine, it was found necessary to replace a small worm and gear. The worm was cut in the usual manner, but the gear, which would ordinarily be cut in a milling machine, had to be cut in the lathe, no milling machine being available. The manner of doing this job may be interesting to some who have not the advantage of working in a large modern shop, where the right kind of machine is supplied for every kind of work.

The worm was cut first, then the hob, the same tool being used to finish both. The hob was made of tool steel in the form of a sleeve, and slipped onto an arbor and fastened with a key and small screw. After being threaded and grooved like a tap, the hob was removed from the arbor and tempered, when it was replaced and ready for work.



Method of Hobbing.

The casting for the gear was then bored and turned to finished size, after which an arbor was made to fasten on the carriage of the lathe in place of the tool post, as indicated in the sketch. The lower nut held the arbor firmly in place. A washer was placed next to the nut; then the gear to be cut, which was a nice fit on the arbor, at that point. A washer was placed on top of the gear, and secured by two nuts, which were adjusted so as to allow the gear to revolve, not too freely.

The arbor containing the hob was then placed on the centers of the lathe, driven by a dog attached to one end of the arbor. The carriage was then raised or lowered to bring the work central. The gear was brought in contact with the revolving hob, and the latter did the rest. The carriage should be fed in at every revolution until the required depth is obtained.

A round wooden box similar in design to those in which figure or letter stamps are sold, will be found very handy, to keep small chisels in. It does not take up much room, and one always knows just where to find his chisels.

I have one I made myself. It is 3½ inches in diameter, holding eighteen assorted chisels, besides the center punch.

Lancaster, N. Y. R. B. CASEY.

* * *

"COMPOUND INDEXING ON THE MILLING MACHINE."

In the letter on the above subject, published in the November issue by John T. Giddings, Providence, R. I., the compound moves for 93 teeth should read $\frac{5}{21}+\frac{11}{33}$ instead of $\frac{5}{21}+\frac{10}{33}$ as erroneously appeared.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

11.—Subscriber: Kindly give me the rule for finding the bursting strength of a flywheel? Please work this out as simply as possible, taking a 20-foot pulley as your example.

A.—It is estimated that 10,000 pounds per square inch is as high a tensile strength as can be assumed safely for the rim of a cast iron flywheel, owing to the probability of unsound castings. A solid rim without joints would burst, if this strength be assumed, at a speed of 1,000 linear feet per second, and so it is quite generally held that a speed of 100 feet per second, or a mile a minute, which gives a factor of safety of 10, is a safe speed for cast iron wheels in general. As a matter of fact there are several other things that often make even this speed too high. The arms do not stretch to the same degree as the rim and act as rigid stays for the rim at intervals, and between the arms the rims bend outward through the action of centrifugal force, introducing bending stresses that reduce the strength of the rim. In most wheels there are rim joints and when these have internal flanges and come midway between the arms, as is customary, they often have less than one-third the strength of the solid rim. There are also internal stresses in both arms and rims, due to the cooling of the iron in the mold. These considerations will show you that any calculations of the bursting strength of flywheels must necessarily be very complicated and they are likely to be of little worth. The best that one can do is to study the different destructive factors entering into the design of a flywheel and so proportion the wheel that the influence of these factors will be reduced to a minimum. After the wheel has been designed, the best way to judge of the speed at which it would let go is to compare with wheels that have burst. If you wish to look into this further, we will refer you to the article upon the design of flywheels, by C. H. Benjamin, in the Oct., '99, number of this paper and in the January, 1899, number will be found an account of some experiments on the bursting speed of flywheels. Both these articles are elementary and easily understood and you will see by the latter that several solid-rim wheels burst at a rim speed of about 400 feet per second; several with rims in halves at a somewhat lower speed; several with internal flanges as low is 180 or 190 feet per second and several with link joints at about 300 feet per second.

12.—H. N. B.: (1) What are the chemical properties of good iron-molding sand? (2) Of what does good brass-molding sand principally consist?

A.—Pure sand, suitable for either iron or brass molding, should contain about 94 parts silica, four or five parts of clay and not over two parts of substances like magnesia, lime, metallic oxides or other substances that will not stand the heat of the molten metal. As for the mixtures of sand with other materials to form a suitable molding sand for different purposes, we must refer you to any of the excellent molders' books, like American Foundry Practice, by Thos. D. West, a new edition of which has just appeared.

13.—J. A. F.: (1) Can you tell me of a coating for highly finished parts of machinery that can be easily removed and that will prevent rusting? (2) I have to finish cast-iron cylinders on the inside only. The cylinders are 3½ inches by 60 to 65 inches long. Can you tell how to finish them and what kind of a machine to use?

A.—(1) If you will apply to any dealer or manufacturer of oils you will be able to obtain a preparation, commonly called "slush," for protecting finished surfaces from rusting. Generally the heavier and dirtier looking this preparation is, the better it will fulfill its purpose. Some use a preparation of white lead and tallow, in such proportions that it will have the necessary consistency for applying with a brush. (2) In lieu of a horizontal boring machine with a bar having sufficient longitudinal travel for the work, you can rig a lathe having a long lathe bed for the job. If the cylinders have a large enough diameter at the start, to allow the introduction of a stiff boring bar, they can be bored by the usual method used in boring any cylinders. The cylinders should be held in a fixture attached to the lathe bed and one end of the bar should be bolted to the lathe carriage for the purpose of feeding through them. This bar should be supported at each end of the cylinder operated upon by fixed sleeves through which the bar can pass longitudinally. Probably a better way, however, will be to bore the cylinders with a bar supported by the lathe carriage at one end and having the cutter or boring tool at the other end. The cutter end of the bar enters one end of the cylinder, operating the same as any drill or boring tool. In this case there are three points to be looked out for in order to have the bit or boring tool take a straight path through the cylinder. First, the tool must be started true; second, the tool must be guided and supported as nearly as possible in a straight line throughout the entire length of the cylinder; third, the tool must cut on its forward or front edge and not on its side edges. Thus, if there were more metal to be removed on one side of the cylinder than on the other, by having the tool cut only on its front edge this extra metal would have no tendency to force the tool toward the opposite side of the cylinder. It is for this reason that it is possible to secure a straighter hole through a cored piece by using a properly supported end mill or similar tool, instead of the usual twist drill. The mill cuts only on its square end, while the drill is ground to a point and tends to "run" to one side or the other, when its beveled edges strike an unusual obstacle. It matters little what form of tool you use as long as this point be kept in mind. To start the tool true you can have either the body of the tool or the bar run in a fixed bushing near the starting point, just as is done in any drilling jig. Or you can bore out one end of each cylinder to the diameter of the boring tool that you are to use, by supporting that end of the cylinder in the center rest of a lathe and driving the other end by the lathe chuck. This bored portion will serve to guide the tool at the start. To guide the tool after it is started, the body of the tool, or of the bar that supports it, must be a good fit in that part of the cylinder that has already been bored. The D drill or "hog" bit, with which you are doubtless familiar, is an efficient tool for this work, as the body of the bit is supported entirely by the finished portion of the hole and the pressure of the cut is thus taken by solid metal, and the possibility of spring is removed. In case you cannot secure enough traverse of the bar to reach entirely through the cylinders, you can drive the tool by collets of different lengths fitting in the end of the bar, starting with a short one and then withdrawing it and introducing a longer one, etc., as the hole advances. While these directions are very meagre, they will probably indicate to one familiar with shop methods the general principles of work of the character mentioned.

14.—A. G.: (1) What is the best way, or what are the tools to use, to cut worm threads from 1-3" to 1-6" pitch in a lathe? I have many worms to cut and I find the work slow, as very light cuts have to be taken to prevent the tool from seizing. I use machine steel the lubricant is good lard oil and the tool is the right shape for the thread, with an equal side clearance of about 12 degrees. I find that a good cut can be taken till the tool gets down about 1-16", after which I can only take cuts not exceeding two-thousandths of an inch. The lathe used is a Hendey-Norton, 24" swing with cross feed graduated in thousandths of an inch. (2) Is there any way by which roughing out cuts can be taken? (3) I notice that most lead screws have the same kind of threads as worms. Can you tell me how these are cut?

A.—(1) The tool must not only have side clearance at the cutting edge, but the under portion must be inclined to the same angle as the threads so as to clear the latter. Assuming that you have attended to all these points of clearance and have the cutting edge properly ground and the tool properly set, we can think of only one possible difficulty, and that is that the work is not supported rigidly enough. Use the follow rest to keep the work up to the tool. (2) With threads as coarse as 1-3 inch pitch, one would naturally use a roughing out tool first, before finishing. It need be no different from the finishing tool other than a little narrower. (3) Lead screws are cut by supporting them with the follow rest back of the tool, and this rest is often made in the form of a bushing in which the screw runs, similar to the rest used on shafting lathes. When thus supported, it is possible to use two or more tools for roughing, just as is done in turning shafting.

15. O. F.—Please tell me how to produce the dull black appearance on wrought iron such as is seen on grills and the so-called "Venetian" iron work.

A.—We shall be glad to have any reader send us his experience with this class of work, stating at the same time the ability of the finish that he has used to resist rusting. A successful process for making iron "non-rusting" consists essentially of heating the piece to be treated red hot and passing over it steam which dissociates and forms free oxygen. The oxygen attacks the surface of the article and forms magnetic or black iron oxide, which effectually protects the surface from rusting. This process, however, is covered by patents.

16. H. R.—What is the amount of the expansion of the gas when it is exploded in a gas engine cylinder? 2.—How much compression is necessary to make a successful explosion in a gas engine?

A.—We will refer you to the January, 1900, number of this paper, where these points are discussed in an article upon gas engine design by E. W. Roberts. He there assumes that a compression space of one-third the piston displacement will represent average practice, and that under this condition the gas would be compressed to about 85 pounds pressure. At the point of explosion the pressure is calculated to be 337 pounds, and this expands to about 50 pounds at the point where the exhaust valve opens. The greater the compression the more economical the engine, and different degrees of compression will give different degrees of expansion. You will be able to calculate any case yourself by the direction given in the article referred to, provided you understand the use of logarithms.

17.—H. G. sends us a sketch of a steam jacketed kettle. From the bottom of the jacket there is a pipe running to the top of a steam boiler and also one running to the bottom of the boiler. The bottom of the jacket is on a level with the water line of the boiler and it is asked why the water will not return to the boiler from the jacket.

A.—Water will return to a boiler from a system of pipes only when the pipes are so placed that there will be a sufficient head of water formed by the condensation of the steam. In this case the pressure in the jacket is practically the same as in the boiler and as the jacket is on a level with the water in the boiler, water would naturally not run from one to the other, except as there might be a slight circulation due to the water being cooler outside than in the boiler. But if the jacket and kettle were raised, then, after the pipe leading to the bottom of the boiler had filled with water, the pressure tending to force the water in the boiler would be the pressure due to this column of water, plus the steam pressure in the jacket. The pressure in the boiler tending to prevent the water from returning would be the steam pressure plus the pressure due to the height of the water in the boiler. As the column of water outside the boiler would be greater than of the water inside, the water would thus tend to run back to the boiler.

Answered by Wm. Baxter, Jr.

18. A. J. J.—Please let me know how galvanized iron is made.

A.—Galvanized iron is made in substantially the same way as tinned iron. The name is misleading, as it creates the impression that the coating of zinc is deposited by galvanic action, when in reality it is obtained by dipping the iron in a pot of melted metal. The process of galvanizing is as follows: The scale is removed from the sheet, or article to be galvanized, by means of a weak solution of sulphuric acid, 16 water to one of acid. A wire brush and sand are used to remove the scale when it has been loosened by the acid. The article is then washed in a hot, moderately strong solution of lye. After the acid has been removed by the lye, the latter is removed with hot water. The article is then dipped in soldering acid, chloride of zinc, and is immersed in a pot of melted zinc. It is allowed to remain in the pot long enough to become thoroughly heated, which may require from five or six seconds to half a minute, depending upon the thickness and size of the article. It is then withdrawn slowly so as to allow the zinc to drain off well, and care is taken that the article is held in such a position that the zinc will not collect in depressions. The surface of the zinc must be kept free from oxide, which is easily accomplished by dropping into the pot small pieces of sal-ammoniac from time to time, and removing the black scum that forms. To obtain entirely satisfactory results a considerable amount of practical experience is required, so as to be able to judge as to the proper temperature of the zinc, the strength of the acid solution, etc., etc.

Answered by E. W. Roberts,

19. U. D. M.—1. I note in the October issue in the "How and Why" column that a clearance space of 50 per cent. of the piston displacement is advised for automobile engines. This is different from the formula given in the articles upon "Gas Engine Design," and I should like to know if it is the practice to give more space for automobile engines than for other purposes. 2. I have heard it claimed that a brake horse-power could be obtained for each 100 square inches of cylinder volume at 100 r. p. m., but according to the formula given in MACHINERY for January, 1900, this is much too small. The party who gave me this rule says that he has seen gas engines do even better. Have you ever heard of similar claims? 3. What is a slide rule as used by Mr. Roberts, and how much do they cost?

A.—1. The clearance advised in the answer to A. K. P. in October is that employed in a *gasoline* engine by a number of makers. While a higher compression is sometimes employed, the writer took into consideration the fact that the engine would probably be built in a shop that is not equipped for the class of work required upon engines having high compression. 2. It is presumed that the inquirer intended to say cubic inches instead of square inches. Assuming that this is true, the rule gives results that are about fifty per cent. greater than those given by the formula referred to. The formula was for average practice. It is evident that the rule is derived from an engine employing a much higher compression than those upon which the formula was based. The writer is doubtful if such results are to be obtained in a commercial engine. 3. The slide rule is a calculating instrument and the price ranges from about $3 up, according to quality and size of the instrument.

20. M. B. C.—Please tell me how to find the pitch of a screw propeller. 2. What is the apparent slip and the negative slip of a propeller? 3. How is the displacement of a vessel figured?

A.—The following answer to your first question is reproduced from the August, '99, number of the paper:

Fig. 1 shows the method of generating a propeller blade as it is swept up in the mould. The sweep A turns with, but is free to slide upon the vertical spindle B. As the outer end of the sweep travels along the edge C D of the guide or former C D E, it will trace a spiral curve of the shape of the face of the blade. If the sweep continued on the same spiral through one complete revolution, the vertical distance that it passed through, measured on the spindle, would be equal to the pitch of the screw. To find the pitch of a propeller after it has been finished,

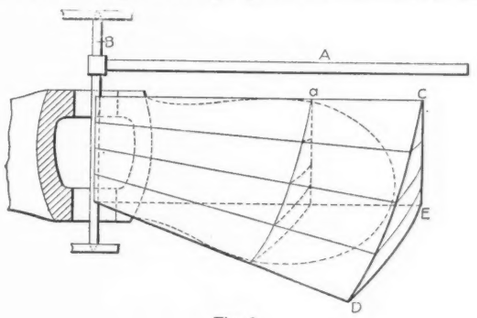


Fig. 1.

set in a horizontal position so that the bore will stand exactly plumb, or in a vertical direction. Cut a strip of wood of a length equal to the bore of the propeller and drive it into the upper end of the bore until it comes flush with the top. On this strip locate the exact center of the bore. Taking this point as a center for a pair of dividers, describe a circle on the upper end of the hub and divide the circle into twelve equal parts, making one of the points of division come in line with the upper edge of the propeller blade. Hold a straight-edge so that one of its edges will pass through this point and also the center of the bore, taking care that the straight-edge is exactly level. With a two-foot rule measure down in a vertical direction from some point on the sweep, as from point A. Now turn the straight-edge around to the next point of division marked on the hub (that is, move it ahead one-twelfth of a turn, or 30 degrees) and measure verti-

cally downward to the blade from the same point, A, on the sweep in its new position. The difference between these two measurements will give the pitch of the propeller in feet. The reason for this is that, since the sweep passed through one-twelfth of a turn and the measurements were taken in inches, or twelfths of a foot, the numerical reading of the rule would be the same as though the sweep had been turned twelve times as far, making one complete revolution, and the measurements had been twelve times as great, or taken in feet. 2. The apparent slip is the difference between the speed of the vessel and the speed of the screw, the latter being determined by multiplying the pitch of the screw by the number of its revolutions. Negative slip is the apparent slip when the water about the screw is to a certain extent following the forward movement of the ship, making the apparent speed of the ship less than it really is. 3. The displacement of a vessel is the weight of the volume of water that it displaces in tons of 2240 pounds. It is found that a vessel will displace from .25 to .35 as much water as a rectangular block having a length, breadth and depth equal to the length, beam and draft of a vessel. Hence, if we multiply together the length, beam and draft of a vessel, all in feet, and this product by, say .3, we shall have the displacement approximately in cubic feet. If we now divide this result by 35, the number of cubic feet of water in one long ton, the result will be the displacement in tons.

* * *

NEW TOOLS OF THE MONTH.

Under this heading are listed the new machine and small tools that have been brought out during the preceding month. Manufacturers are requested to send brief descriptions of their new tools as they appear, for use in this column.

The American Gas Furnace Co., New York, have recently designed a round hardening furnace especially for hardening steel rolls. The rolls are not encased, but are covered with a carbonaceous paste that is supplied. They are heated uniformly and are comparatively free from springing when treated in this way. The furnaces may be made for rolls or long pieces of any size or description.

MACHINISTS' TOOLS.

The bevel protractor illustrated herewith has recently been brought out by the Sawyer Tool Co., Fitchburg, Mass., and has several features to which they call attention. The stock is well proportioned with good width of face. The polished rib at the back greatly strengthens and improves the appearance of the tool.

Fig. 1. Bevel Protractor.

A level permanently attached to the turret makes an excellent inclinometer of the instrument. The fact of not having to remove the blade when using the level will many times be found convenient.

A combination set has also been produced containing a square, protractor and a center head, one blade being used for all. In this set as well as with the bevel protractor the blade is hardened and carefully ground.

ACCURATE GEAR PATTERNS.

The accompanying illustration is from a photograph sent us by the Buffalo Gear and Pattern Works, Buffalo, N. Y., showing the character of pattern work that is being turned out by them.

For many years most of the gearing used was cast from wooden patterns made by hand labor, that is necessarily more or less imperfect. If it were possible to have perfectly cast gears, they would in many cases have undoubted advantages over cut gears, especially when it is desired to use "herring bone" or spiral teeth of large size, making the cost of production excessive. To this end the Buffalo Gear and Pattern Works make a specialty of gear patterns with teeth formed by machinery and have special

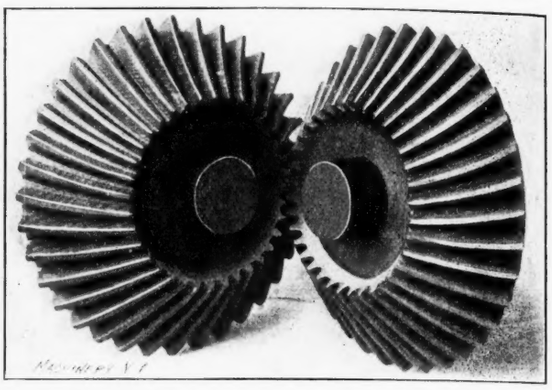


Fig. 2. Patterns for Bevel Gears, with Curved Teeth.

machines for making patterns for helical, bevel and worm gears, which it is extremely difficult to produce by hand processes. They are also introducing miter and bevel gears with curved teeth, like those of the illustration. These teeth advance spirally, the effect of which is to produce continuous and smooth driving and an attendant reduction in the noise. Herring bone patterns are also made by machine processes for cases where a large amount of power is to be transmitted. A point of preference often expressed for cast gears is their ability to resist wear because of the fact that the skin of the metal has not been removed and it would seem that the introduction of all kinds of accurately made patterns would increase the field of usefulness for cast gears.

GLOBE TOOL SHARPENER-PLANE GRINDING MACHINE USING MAGNETIC CHUCKS.

O. S. Walker & Co., Worcester, Mass., have recently brought out the tool sharpener, shown in the accompanying cut, Fig. 3.

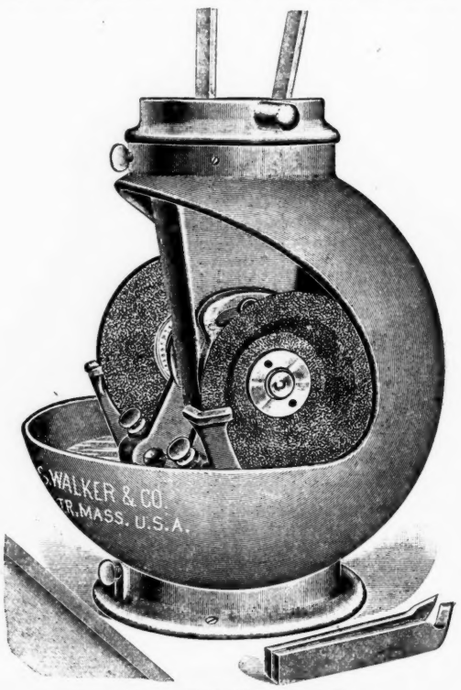


Fig. 3. Bench Tool Sharpener.

It is not intended to take the place of a regular toolroom grinder, but is to be used in the shop for retouching tools that have become only slightly dulled, and thus save time and travel to the workmen. The sharpener is made, either to set on the bench, or with a column to set on the floor.

The machine is very conveniently arranged to obtain the best light and position of the wheels. The wheels are arranged to swivel relative to the outer shell or globe by loosening the thumbnut shown at the top. The frame carrying the wheels and belt pulley can then be turned almost entirely around relative to the globe. If, after getting the wheels in a convenient position relative to the globe, the light does not strike the work from a favorable direction, the globe itself with the wheels can be swiveled by loosening the thumbnut shown at the bottom.

The lower part of the spherical case contains water which is not, however, in contact with the wheels as the machine is designed to be a dry grinder. The water is provided for catching the debris from grinding and to provide a convenient means of cooling the piece being ground. The interior of the shell is enameled white to reflect the light on the tool being ground.

The wheels are mounted on a conical spindle, shells of the correct taper to fit the spindle and the wheels being provided. With this arrangement a wheel can be removed and another substituted in a moment without the use of tools and with the certainty that the new wheel will run correctly on the arbor if it has been once trued on it.

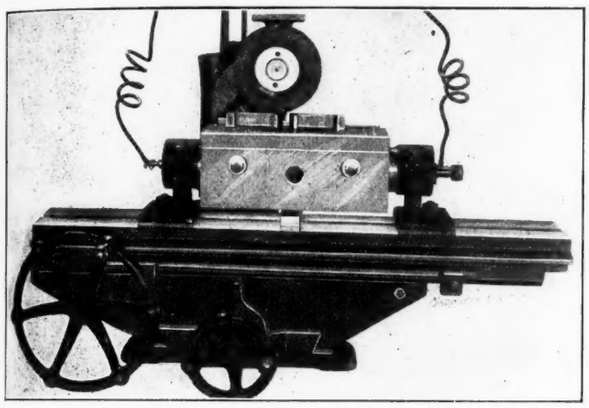


Fig. 4. Plane Grinding Machine, with Magnetic Chuck.

The spindle runs in conical bearings provided with means of taking up the wear and preventing the entrance of emery dust. As will be seen, the belt is entirely encased with the pulley up to the top of the machine.

The plane grinding machine shown in Fig. 4 is designed to be used in connection with the well-known magnetic chucks manufactured by this company. The platen has a longitudinal and transverse movement controlled by the handwheels shown in front. The square magnetic chuck on top is swiveled on graduated bearings at the ends, so that any bevel may be ground. Work may be held either on the side or the top of the chuck. The wheel is arranged to work on top of the chuck or on the side, being mounted on a hollow piece arranged to slide on a round vertical pillar. By an ingenious arrangement of idler pulleys, the belt length remains the same whatever the vertical position of the wheel, and also when turned around at right angles to the position shown, to use the edge of the wheel against the side of the chuck, if desirable.

This grinder is well adapted to grinding the edges of bevel pieces and truing the edges of thin triangular pieces and similar work. It is also used to advantage in surfacing thin pieces of eccentric shape, such as gun hammers and triggers, and, of course, an infinite variety of other work of the same character. On such pieces the full capacity of the chuck can be used, the wheel traversing over them and making them all of uniform thickness and with absolutely parallel sides.

* * *

A Spanish gentleman in Paris recently attempted to call up a friend on the telephone, but instead found himself in conversation with a stranger. He lost his temper and wreaked vengeance on the telephone by firing four shots into it, totally wrecking the instrument.

In some parts of Germany, considerable attention is being paid to electrical appliances that can be used on the farm. Near Ochsenfurt, in Bavaria, a company composed of landowners and small farmers has been organized for the establishment of an electrical system for use on their farms and in villages. The power is to be generated by steam and water and the current to be distributed from a central station to the places at which it is wanted. Substations are to be established at given points, with the necessary apparatus for connecting with the farm or other machinery and also for lighting purposes in the houses, offices, roads, and village streets.

* * *

No better center for a technical school could be imagined than Pittsburg, with its diversified iron industries, and Mr. Andrew Carnegie evidently appreciates this fact through his reported gift of $3,000,000 to found a "Carnegie Institute of Technology" in that city. Aside from Mr. Carnegie's numerous gifts for free libraries, he has already shown his interest in technical education by a gift of $250,000 to the Polytechnic School of Birmingham, England, by $50,000 given to a school in Scotland, and by $50,000 given to Stevens Institute, Hoboken. If Mr. Carnegie's intentions with regard to this new enterprise are correctly reported, his total gifts for schools and libraries at Pitttsburg will amount to over $8,000,000.

* * *

The American Society of Mechanical Engineers will hold their forty-second meeting in this city from December 4 to 7. The opening session will take place on Tuesday, December 4. At the second session, Wednesday morning, the following papers will be taken up: "Comparison of Rules for Calculating the Strength of Steam Boilers," by H. deB. Parsons; "A Record of the Early Period of High-Speed Engineering," by Chas. T. Porter, and "Steam Engine of Maximum Simplicity and of Highest Thermal Efficiency," by Robert H. Thurston. There will be three other sessions between Wednesday and Friday evening, at which equally important and interesting subjects will be treated.

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FRESH FROM THE PRESS.

American Foundry Practice, by Thomas D. West. 10th edition, revised, with new matter added. Published by John Wiley & Sons, New York. 408 12mo pages, illustrated. Price $2.50.

This book is so well known as one of the standard works on foundry practice that it does not require an extended notice. Attention should be called to the fact that while the first edition was published 17 years ago, the demand for the book is as great now as at any previous time. The author presents in this volume a general treatment of the principles of foundry practice, leaving some of the more advanced and special topics for his later work, the "Molders' Text Book." By the revision of "American Foundry Practice," however, it has been brought up to the times, wherever foundry methods have changed, representing modern practice and forming a fit companion to the volume.

Molders' Text Book, by Thos. D. West. 8th edition, fully revised. Published by John Wiley & Sons, New York. Price $2.50. 460 12mo. pages, illustrated.

Following the revision of American Foundry Practice, by Thos. D. West, noticed above, has come the revision of this book, which is really Part 2 of the earlier volume. This volume is quite as well known among those connected with the foundry throughout the country as the earlier one. It treats more in detail of various departments of foundry work than could be done in a general text book, giving, for example, much attention to cranes, to cupola practice and difficult molding in loam and dry sand. Considerable new matter has been added in this revision, and any parts that were obsolete have been brought up to date. The author states that he considers the information now given to be as valuable to the trade to-day as when the book first appeared in 1885.

Free-hand Perspective, by Victor T. Wilson, Instructor in Drawing, Cornell University. Published by John Wiley and Sons, New York. 268 8vo. pages. illustrated. Price $2.50.

There are many excellent books already upon the market treating of perspective. There is none besides this work, however, that presents the science of linear perspective for the benefit of technical students and draftsmen, who care less about the artistic treatment of a subject and more about the ability to make free-hand sketches technically correct, both as regards the subject and the method of treatment. The book may be described as one adapted to the needs of students of engineering, especially of mechanical engineering and of draftsmen artistically inclined who want to cultivate the ability to put

some of their ideas on paper in perspective instead of in projection. The course outlined has been employed by the author for students in mechanical engineering at Cornell University. The list of contents is as follows: Planes and their vanishing points; To find the vanishing points of lines; The measurements of lines; The treatment of curves; The estimation of values of plane angles; Methods of applications and distortions; Changes in form due to changes in position; Problems in tangent and intersecting planes; Phenomena of shadows and their perspective treatment; Perspective sketches from working drawings. The book contains many original drawings and quite a number showing the application of the principles to drawing machine parts.

The Progress of Invention of the Nineteenth Century, by Edward W. Byrn, A. M. Published by Munn & Co., 361 Broadway, New York, 476 8vo. pages, illustrated. Price, $3.00.

This is a carefully prepared book by a competent authority, and while it is written in a popular vein, the information given is taken largely from the patent records and is as reliable, probably, as it would be possible to obtain. There is a brief chronological history of some of the most important inventions, and then follow chapters devoted to the development of different departments of science and mechanics. None of the chapters treat exhaustively of their subjects, this being not only impossible in a book of reasonable size, but unnecessary in a general work of this character, designed for non-technical readers. Among the subjects mentioned are electricity, civil engineering, rubber, optics, chemistry, gas, surgery, food and drink, besides several lines of industry dependent upon machinery, like steam navigation, printing, agriculture, etc.,

Our chief adverse criticism is with regard to what has been omitted in preparing the work, rather than with the contents as they are. There is no information, for example, about machine tools, or machine shop development. While a chapter is devoted to liquid air, one to X-rays, and one to the phonograph, the gas engine, or hydraulics, are barely mentioned. In many instances the history of the early part of the century seems to be quite fully traced, while that of the latter part is rapidly skimmed over, and is far from complete. In the locomotive chapter, for example, it is stated, merely, that one of the recent developments is the compound locomotive, with no attempt to show what the important changes in the locomotive have been during the past quarter of a century. We mention these omissions so that the student will not be misguided in consulting the pages of the work. For the purposes of the average reader it will prove both interesting and profitable.

ADVERTISING LITERATURE.

We have received the following catalogues and trade circulars:

Manning, Maxwell & Moore, 85-89 Liberty street, New York. Illustrated catalogue of machine tools and attachments. This is one of the largest and most complete catalogues of machine tools and appliances for the machine shop issued by any firm. It contains over 700 large pages profusely illustrated and showing every variety of tool needed for the complete equipment of any shop, however large or small their class of work may be. In addition to machine tools are descriptions of woodworking machinery, and this house also issues another catalogue in which are listed supplies for the use of railways, steamships, machinists, contractors, etc. There are also to be found tools for structural iron work and for the blacksmith shop. So many manufacturing firms are represented by this house that their catalogue contains a large and varied assortment of tools for every variety of work.

The S. Obermayer Company, Chicago, Ill., and Cincinnati, O. Catalogue and price list of "Everything for the Foundry." This is a 6 x 9 standard size pamphlet containing lists and descriptions of everything that can possibly be required for foundry use except iron and fuel. Not only are the appliances and supplies, like facings, sand, flasks, riddles, wheelbarrows, scales, ladles, etc., listed, but the larger appliances, like cranes, cupolas, blowers, pneumatic hoists, core ovens, brass furnaces, molding machines, etc., are all included in the extensive table of contents that this book contains. There are also many of the supplies that are required for pattern makers' use. It is the most complete catalogue of the kind that we have seen and will be sent to the address of any person interested in foundry work of any description.

Chicago Flexible Shaft Company, Chicago, Ill. Illustrated catalogue of the Stewart gas blast furnace and rotary pressure blowers. These furnaces are made for a great variety of purposes, where it is desired to secure uniformity in heating work, and they can be adapted to different grades of gas.

The F. W. Emerson Manufacturing Company, Rochester, N. Y. Catalogue of drafting-room furniture, such as drawing tables, cabinets, blue-printing frames, desks, etc. There is a great variety of drawing tables for both home and drawing-office use.

Cleveland Pneumatic Tool Company, Cleveland, O. Illustrated catalogue of pneumatic hammers of different sizes, pneumatic riveters and portable air drills. There are numerous illustrations.

The Sprague Electric Company, 527 West 34th street, New York. Circular of electric motors designed especially for automobiles.

Hilles & Jones Company, Wilmington, Del. Catalogue of machinery for working sheet metal and structural steel. Punches, shears, coping and notching machines, plate rolls, etc., are listed and illustrated.

Auburn Ball Bearing Company, Auburn, N. Y. Illustrated circular of ball bearings. These are made in the form of thrust bearings, loose pulley bearings and bearings for shafting. There are also special designs of hangers illustrated, for use in connection with the shafting bearings.

L. S. Starrett, Athol, Mass. Circulars of several of their machinists' tools, hack saws, nail sets, etc. These are prepared in an attractive style, for convenient distribution.

Joseph Dixon Crucible Company, Jersey City, N. J. Circular of Dixon's silica-graphite paint for the protection of steel viaducts, bridges and other iron and steel work exposed to sulphur fumes of locomotives.

A handy little celluloid bill file has been received from the Springfield Machine Tool Company, Springfield, O., manufacturers of brass, iron and steel-working machinery. The company will be pleased to send one to any one using their machine tools.

We have received from the Magnolia Metal Company, New York, Chicago and Montreal, a 14" rule, on the back of which this company call attention to the metal manufactured by them for steamship, railway, dynamo, rolling mill and all machinery bearings.

A convenient little celluloid pocket rule has been received from the Saginaw Manufacturing Company, Saginaw, Mich. This company manufacture the Gilbert wood split pulleys and also special iron center pulleys for main drives and dynamo work, also tight and loose cone, flange and all other kinds of special pulleys. It will be sent to any machinist.

MANUFACTURERS' NOTES.

The Hyatt Roller Bearing Company, Harrison, N. J., have secured the contract for the shafting equipment of the Raymond Manufacturing Company, Guelph, Ontario; also the equipment for the Roanoke Mills, No. 2, of the Patterson Textile Company, Roanoke Rapids, N. C., and of the power transmission machinery, including two quill outfits in the power house of the Roanoke Navigation and Water Power Company, Roanoke Rapids, N. C.

Ambitious mechanics desiring better positions and higher wages should investigate the Free Scholarship offer made, in another column, by the American School of Correspondence, Boston, Mass. Instruction papers, prepared especially for teaching by mail and free as possible from technicalities, are furnished free, as well as special information regarding any difficulties in their studies.

Mr. J. H. Jann formerly connected with the Western Electric Company, Chicago, informs us that he and Mr. Shank, formerly foreman for the Chicago Screw Company, have started in business as manufacturers of high grade tools. The new company will be known as The Western Tool Works, and are located corner Canal and Randolph streets, Chicago. They are prepared to execute orders of any kind in special machinery, experimental work, etc.

Mr. E. G. Acheson, president of the Carborundum Company, Niagara Falls, N. Y., has recently received from Paris the award of "Grand Prix" for his individual exhibit of the carborundum products.

H. F. Frevert, formerly with the Garvin Machine Company, has associated himself with the Niles Tool Works Company, and will be located at the general offices and salesrooms of this company, 136 Liberty street, New York, where he will be pleased to see all those interested in their machine tools.

The Bignall & Keeler Manufacturing Company, Edwardsville, Ill., manufacturers of Peerless and Duplex pipe-threading and cutting machines, report an excellent run of business. Among their recent sales are those made to the Tri-Mountain Mining Company, Houghton, Mich.; Aermeter Company, Chicago; Mark Manufacturing Company, Chicago; P. C. C. & St. L. Railway Company, Pullman Car Company, United States Naval Academy, Annapolis, and others.

Mr. Jos. H. Williamson, for nearly eighteen years business manager of the Manufacturers' Advertising Agency, New York, has connected himself with the Viennot Advertising Agency, 524 Walnut street, Philadelphia. Mr. Williamson wishes to announce that he will be glad to welcome his many friends at his new address, either at the office in Philadelphia or at the New York office, 127 Duane street.

The Toledo Machine & Tool Company, Toledo, O., report that since removing in 1898 to their present enlarged quarters they have added largely to their equipment and have more than trebled their capacity for producing punch presses and special tools for sheet and bar metal work. They are also giving considerable attention to equipping plants for shovel manufacturers.